

1A* PWM/VFM Dual Step-down DC/DC Converter with Synchronous Rectifier

NO.EA-285-120328

OUTLINE

RP550K001A is a CMOS-based 1A* dual step-down DC/DC converter with synchronous rectifier. Internally, each converter consists of oscillators, reference voltage units, error amplifiers, switching control circuits, soft-start circuit, latch type protection circuit, an under voltage lockout (UVLO) circuit, a thermal shutdown circuit and switching transistors.

By adopting a synchronous rectifier with built-in switching transistors, a low ripple high efficiency synchronous rectifier step-down DC/DC converter can be easily configured with simply using two inductors, resistors and capacitors as the external components. RP550K001A is available in DFN(PLP)2730-12 package which achieves high-density mounting on boards. Output voltage is adjustable with external divider resistors.

Latch type protection circuit latches the built-in driver to the OFF state during high load or if the output is short-circuited for a specified time (protection delay time). The latch type protection circuit can be released by once setting the converter into the standby mode with the CE pin and then setting it back to the active mode, or, by turning the power off and back on. Setting the supply voltage lower than the UVLO detector threshold can also release the latch type protection circuit. Thermal shutdown circuit detects overheating of the converter and stops the converter operation to protect it from damage if the junction temperature exceeds the specified temperature.

By inputting a signal to MODE pin, RP550K001A can choose PWM/VFM auto switching control or forced PWM control. In low output current, PWM/VFM auto switching control automatically switches from PWM mode to VFM mode in order to achieve high efficiency. Likewise, in low output current, forced PWM control switches at fixed frequency in order to reduce noise.

When the both converters are in PWM mode, the converters operate with 180° turn-on phase shift of the switching transistors.

* This is an approximate value; output current depends on conditions and external components.

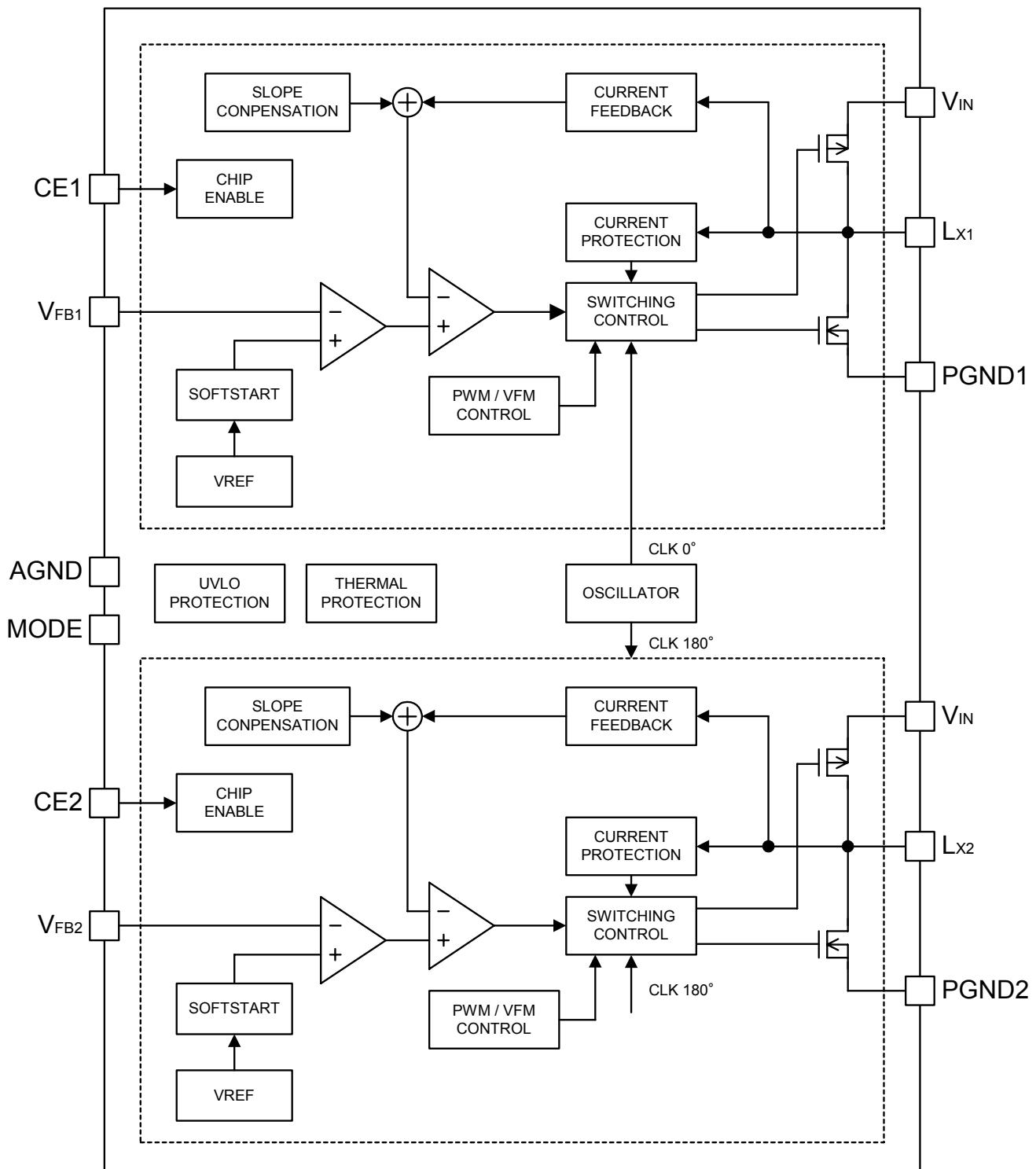
FEATURES

- Supply Current Typ. 45 μ A (VFM mode with no load/ 1 channel)
- Standby Current Max. 10 μ A
- Input Voltage Range 2.3V to 5.5V ($V_{SET} \geq 0.8V$)
- Output Voltage Range Adjustable from 0.6V (Recommended range is up to 3.3V)
- Feedback Voltage Accuracy $\pm 9mV$ ($V_{FB}=0.6V$)
- Output Voltage Temperature Coefficient $\pm 100ppm/^\circ C$
- Oscillator Frequency Typ. 2.25MHz
- Oscillator Maximum Duty Min. 100%
- Built-in Driver ON Resistance Typ. Pch. 0.25 Ω , Nch. 0.21 Ω ($V_{IN}=3.6V$)
- UVLO Detector Threshold Typ. 2.0V
- Soft Start Time Typ. 0.2ms
- Lx Current Limit Circuit Typ. 1700mA/ channel
- Latch Type Protection Circuit Typ. 1.5ms
- Package DFN(PLP)2730-12

APPLICATION

- Power source for portable communication equipment, camcorder, DSC, Notebook PC
- Power source for HDD, WLAN
- Power source for Li-ion battery-used equipment

BLOCK DIAGRAM

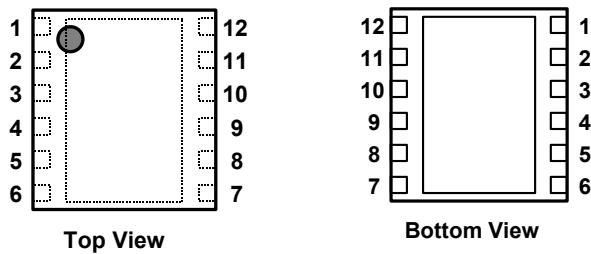


SELECTION GUIDE

| Product Name | Package | Quantity per Reel | Pb Free | Halogen Free |
|---|-----------------|-------------------|---------|--------------|
| RP550K001A-TR | DFN(PLP)2730-12 | 5,000pcs | Yes | Yes |
| Output voltage is adjustable with external divider resistors. | | | | |
| Recommended output voltage range is from 0.6V to 3.3V. | | | | |

PIN CONFIGURATIONS

- DFN(PLP)-2730-12



PIN DESCRIPTIONS

- **RP550K001A: DFN(PLP)2730-12^{*1}**

| Pin No. | Symbol | Description |
|---------|-----------|--|
| 1 | V_{FB2} | Channel 2 Feedback Pin |
| 2 | MODE | Mode Control Pin ("H" Forced PWM Control, "L" PWM/VFM Auto Switching Control) |
| 3 | V_{IN} | Input Pin ^{*2} |
| 4 | V_{IN} | Input Pin ^{*2} |
| 5 | AGND | Analog Ground Pin ^{*3} |
| 6 | V_{FB1} | Channel 1 Feedback Pin |
| 7 | CE1 | Channel 1 Chip Enable Pin ("H" active) |
| 8 | L_{x1} | Channel 1 L_x Switching Pin |
| 9 | PGND1 | Channel 1 Power Ground Pin ^{*3} |
| 10 | PGND2 | Channel 2 Power Ground Pin ^{*3} |
| 11 | L_{x2} | Channel 2 L_x Switching Pin |
| 12 | CE2 | Channel 2 Chip Enable Pin ("H" active) |

¹ The tab on the bottom of the package enhances thermal performance and is electrically connected to GND (substrate level). It is recommended that the tab be connected to the ground plane on the board. If not, the tab can be left open.

*² No.3 pin and No.4 pin must be wired to the V_{IN} plane when mounting on boards.

³No.5 pin, No.9 pin and No.10 pin must wired to the GND plane when mounting on boards.

ABSOLUTE MAXIMUM RATINGS

(AGND=PGND1=PGND2=0V)

| Symbol | Item | Rating | Unit | |
|--------------------|-------------------------------------|---|------|----|
| V_{IN} | V_{IN} Input Pin Voltage | -0.3 to 6.5 | V | |
| V_{LX1}, V_{LX2} | L_{x1}, L_{x2} Pin Voltage | -0.3 to $V_{IN} + 0.3$ | V | |
| V_{CE1}, V_{CE2} | CE1, CE2 Pin Voltage | -0.3 to 6.5 | V | |
| V_{MODE} | MODE Pin Voltage | -0.3 to 6.5 | V | |
| V_{FB1}, V_{FB2} | V_{FB1}, V_{FB2} Pin Voltage | -0.3 to 6.5 | V | |
| I_{LX1}, I_{LX2} | L_{x1}, L_{x2} Pin Output Current | 1.7 | A | |
| P_D | Power Dissipation ^{*1} | Standard Land Pattern ^{*1} | 1000 | mW |
| | | High Wattage Land Pattern ^{*1} | 1950 | mW |
| T_a | Operating Temperature Range | -40 to +85 | °C | |
| T_{stg} | Storage Temperature Range | -55 to +125 | °C | |

^{*1} For more information about Power Dissipation, Standard Land Pattern and High Wattage Land Pattern, please refer to PACKAGE INFORMATION.

ABSOLUTE MAXIMUM RATINGS

Electronic and mechanical stress momentarily exceeded absolute maximum ratings may cause the permanent damages and may degrade the lifetime and safety for both device and system using the device in the field. The functional operation at or over these absolute maximum ratings is not assured.

RECOMMENDED OPERATING CONDITIONS (ELECTRICAL CHARACTERISTICS)

All of electronic equipment should be designed that the mounted semiconductor devices operate within the recommended operating conditions. The semiconductor devices cannot operate normally over the recommended operating conditions, even if when they are used over such conditions by momentary electronic noise or surge. And the semiconductor devices may receive serious damage when they continue to operate over the recommended operating conditions.

ELECTRICAL CHARACTERISTICS

Test Circuit is "OPEN LOOP" and Test Condition is AGND=PGND1=PGND2=0V, unless otherwise noted.

● RP550K001A

(Ta=25°C)

| Symbol | Item | Conditions | Min. | Typ. | Max. | Unit |
|-----------------------------------|---|---|-------|-------|-------|--------|
| V _{IN} | Operating Input Voltage | 0.8V ≤ V _{SET} ^{*2} | 2.3 | | 5.5 | V |
| | | 0.6V ≤ V _{SET} < 0.8V | 2.3 | | 4.5 | |
| V _{FB} | Feedback Voltage | V _{IN} =V _{CE1,2} =3.6V | 0.591 | 0.600 | 0.609 | V |
| ΔV _{FB} /ΔT _a | Output Voltage Temperature Coefficient | -40°C ≤ Ta ≤ 85°C | | ±100 | | ppm/°C |
| f _{osc} | Oscillator Frequency | V _{IN} =V _{CE1,2} =3.6V | 2.00 | 2.25 | 2.50 | MHz |
| I _{DD1} | Supply Current 1 ^{*1} | V _{IN} =V _{CE1,2} =5.5V, V _{FB1,2} =0.45V, V _{MODE} =0V | | 800 | 1100 | μA |
| I _{DD2} | Supply Current 2 ^{*1} | V _{IN} =V _{CE1,2} =5.5V, V _{FB1,2} =0.75V, V _{MODE} =0V | | 45 | 60 | μA |
| I _{DD3} | Supply Current 3 ^{*1} | V _{IN} =V _{CE1,2} =5.5V, V _{FB1,2} =0.75V, V _{MODE} =5.5V | | 800 | 1100 | μA |
| I _{Standby} | Standby Current ^{*1} | V _{IN} =5.5V, V _{CE1} =V _{CE2} =0V | | 0 | 10 | μA |
| I _{CEH} | CE "H" Input Current ^{*1} | V _{IN} =5.5V, V _{CE1,2} =5.5V | -1 | 0 | 1 | μA |
| I _{CEL} | CE "L" Input Current ^{*1} | V _{IN} =5.5V, V _{CE1,2} =0V | -1 | 0 | 1 | μA |
| I _{MODEH} | MODE "H" Input Current | V _{IN} =V _{MODE} =5.5V | -1 | 0 | 1 | μA |
| I _{MODEL} | MODE "L" Input Current | V _{IN} =5.5V, V _{MODE} =0V | -1 | 0 | 1 | μA |
| I _{FBH} | V _{FB} "H" Input Current ^{*1} | V _{IN} =V _{FB1,2} =5.5V, V _{CE1,2} =0V | -1 | 0 | 1 | μA |
| I _{FBL} | V _{FB} "L" Input Current ^{*1} | V _{IN} =5.5V, V _{CE1,2} =V _{FB1,2} =0V | -1 | 0 | 1 | μA |
| I _{LXLEAKH} | Lx Leakage Current "H" ^{*1} | V _{IN} =V _{LX1,2} =5.5V, V _{CE1,2} =0V | -1 | 0 | 5 | μA |
| I _{LXLEAKL} | Lx Leakage Current "L" ^{*1} | V _{IN} =5.5V, V _{CE1,2} =V _{LX1,2} =0V | -5 | 0 | 1 | μA |
| V _{CEH} | CE "H" Input Voltage | V _{IN} =5.5V | 1.0 | | | V |
| V _{CEL} | CE "L" Input Voltage | V _{IN} =2.3V | | | 0.4 | V |
| V _{MODEH} | MODE "H" Input Voltage | V _{IN} =5.5V | 1.0 | | | V |
| V _{MODEL} | MODE "L" Input Voltage | V _{IN} =2.3V | | | 0.4 | V |
| R _{ONP} | Pch Transistor ON Resistance | V _{IN} =3.6V, I _{LX1,2} =-100mA | | 0.25 | | Ω |
| R _{ONN} | Nch Transistor ON Resistance | V _{IN} =3.6V, I _{LX1,2} =-100mA | | 0.21 | | Ω |
| Maxduty | Oscillator Maximum Duty Cycle | | 100 | | | % |
| tstart | Soft-start Time | V _{IN} =V _{CE1,2} =3.6V | | 200 | 300 | μs |
| I _{LXLIM} | Lx Limit Current | V _{IN} =V _{CE1,2} =3.6V | 1400 | 1700 | | mA |
| tprot | Protection Delay Time | V _{IN} =V _{CE1,2} =3.6V | 0.5 | 1.5 | 5 | ms |
| V _{UVLO1} | UVLO Detector Threshold | V _{IN} =V _{CE1,2} | 1.9 | 2.0 | 2.1 | V |
| V _{UVLO2} | UVLO Released Voltage | V _{IN} =V _{CE1,2} | 2.0 | 2.1 | 2.2 | V |
| T _{TSD} | Thermal Shutdown Temperature | Junction Temperature | | 140 | | °C |
| T _{TSR} | Thermal Shutdown Released Temperature | Junction Temperature | | 100 | | °C |

*¹ For Standby Current, the sum of Channel 1 and Channel 2 is indicated.

As for the following currents, either Channel 1 or Channel 2 is indicated.

- Supply Current 1 to Supply Current 3

- CE “H” Input Current

- CE “L” Input Current

- V_{FB} “H” Input Current

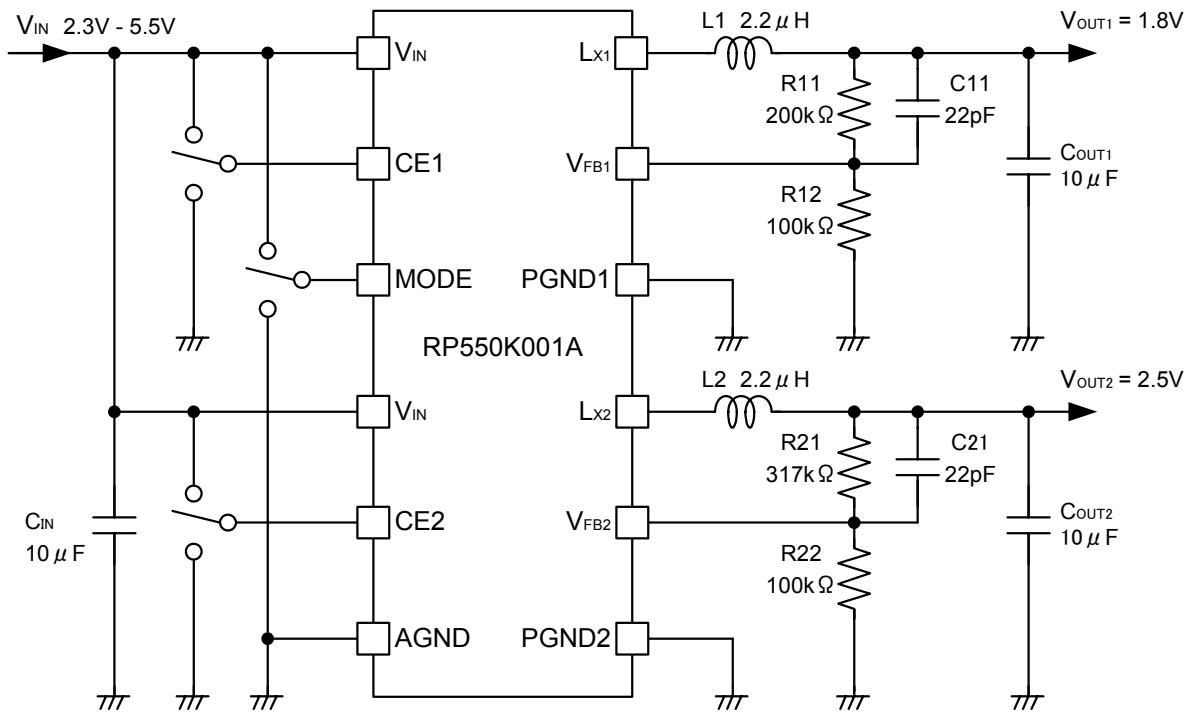
- V_{FB} “L” Input Current

- L_x Leakage Current “H”

- L_x Leakage Current “L”

*² V_{SET} = Setting Output Voltage

TYPICAL APPLICATION



Note: MODE= "H" Forced PWM Control
 MODE= "L" PWM/VFM Auto Switching Control

- $0.8V \leq V_{SET} \leq 3.3V$

| Symbol | Recommended Components | | |
|-----------|------------------------|-------------------|---------------------|
| C_{IN} | 10 μ F | Ceramic Capacitor | C1608JB0J106M (TDK) |
| C_{OUT} | 10 μ F | Ceramic Capacitor | C1608JB0J106M (TDK) |
| L | 2.2 μ H | Inductor | MIPSA2520D2R2 (FDK) |

- $0.6V \leq V_{SET} < 0.8V$

| Symbol | Recommended Components | | |
|-----------|------------------------|-------------------|---------------------|
| C_{IN} | 10 μ F | Ceramic Capacitor | C1608JB0J106M (TDK) |
| C_{OUT} | 10 μ F \times 2 | Ceramic Capacitor | C1608JB0J106M (TDK) |
| L | 1.5 μ H | Inductor | MIPSA2520D1R5 (FDK) |

TECHNICAL NOTES

When using RP550K001A, please consider the following points.

- AGND, PGND1 and PGND2 must be wired to the GND plane when mounting on boards.
- V_{IN} pins must be wired to the V_{IN} plane when mounting on boards.
- Ensure the V_{IN} and GND lines are sufficiently robust. A large switching current flows through the GND line, the V_{DD} line, the V_{OUT} line, an inductor, and L_X . If their impedance is too high, noise pickup or unstable operation may result. Set the external components as close as possible to the IC and minimize the wiring between the components and the IC. Especially, place the capacitor as close as possible to the V_{IN} pin and GND. Separate the wiring between a resistor for setting output voltage (R11/ R21) and an inductor (L1/ L2) from the wiring between a capacitor (C11/ C21) and L1/ L2.
- Choose a low ESR ceramic capacitor. The ceramic capacitance of a capacitor (C_{IN}) connected between V_{IN} and GND should be more than or equal to $10\mu F$. The ceramic capacitance of a capacitor (C_{OUT}) connected between V_{OUT} and GND should be $10\mu F$ to $20\mu F$. Please be aware of the characteristics of bias dependence and temperature fluctuation of ceramic capacitor.
- The phase compensation of this IC is designed according to the above C_{OUT} values and L values. For stable operation, a ceramic capacitance value and an inductance value have to be selected within these values. Choose an inductor that has small DC resistance, has enough allowable current and is hard to cause magnetic saturation. If the inductance value of an inductor is extremely small, the peak current of L_X may increase along with the load current. As a result, over current protection circuit may start to operate when the peak current of L_X reaches to “ L_X limit current”.
- Over current protection circuit and latch type protection circuit may be affected by self-heating or power dissipation environment.
- The output voltages (V_{OUT1} , V_{OUT2}) are adjustable by changing the values of R11, R12, R21, and R22 as follows.

$$V_{OUT1} = 0.6 \times (R11 + R12) / R12 \quad (\text{Recommended range: } 0.6V \leq V_{OUT1} \leq 3.3V)$$

$$V_{OUT2} = 0.6 \times (R21 + R22) / R22 \quad (\text{Recommended range: } 0.6V \leq V_{OUT2} \leq 3.3V)$$

- If R11, R12, R21, and R22 are too large, the impedances of V_{FB1} and V_{FB2} also become large, as a result, the IC could be easily affected by noise. For this reason, R12 and R22 should be $100k\Omega$ or less. If the operation becomes unstable due to the high impedances, the impedances should be decreased.
- C11 and C21 can be calculated by the following equations. Please use the value close to the calculation result.

$$C11 = 2.2 \times 10^{-6} / R12 \text{ [F]} \quad (0.6V \leq V_{OUT1} \leq 3.3V)$$

$$C21 = 2.2 \times 10^{-6} / R22 \text{ [F]} \quad (0.6V \leq V_{OUT2} \leq 3.3V)$$

- The recommended resistance values for R11, R12, R21, R22, C11, and C21 are as follows.

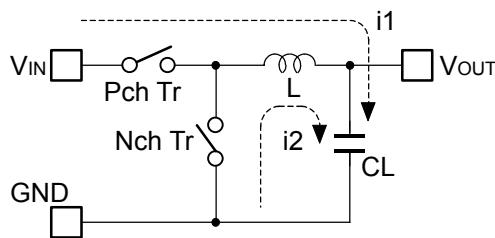
| V_{OUT1} , V_{OUT2} [V] | 0.6 | 0.7 | 0.8 | 1.2 | 1.8 | 2.5 | 3.3 |
|-----------------------------|-----|------|------|-----|-----|-----|-----|
| R11, R21 [$k\Omega$] | 0 | 16.7 | 33.3 | 100 | 200 | 317 | 450 |
| R12, R22 [$k\Omega$] | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| C11, C21 [pF] | - | 22 | 22 | 22 | 22 | 22 | 22 |

- ★ The performance of power source circuits using this IC largely depends on the peripheral circuits. When selecting the peripheral components, please consider the conditions of use. Do not allow each component, PCB pattern and the IC to exceed their respected rated values (voltage, current, and power) when designing the peripheral circuits.

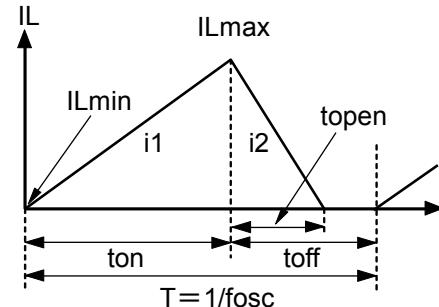
OPERATION OF STEP-DOWN DC/DC CONVERTER AND OUTPUT CURRENT

The step-down DC/DC converter charges energy in the inductor when L_x Tr. turns “ON”, and discharges the energy from the inductor when L_x Tr. turns “OFF” and controls with less energy loss, so that a lower output voltage (V_{OUT}) than the input voltage (V_{IN}) can be obtained. The operation of the step-down DC/DC converter is explained in the following diagrams.

Diag. 1 Basic Circuit



Diag. 2 Inductor (L) Current



Step 1: Pch Tr. is “ON” and current $IL=i1$ flows, and energy is charged into CL . At this moment, in proportion to the time while Pch Tr. is “ON” (t_{ON}), $IL=i1$ increases from $IL=IL_{MIN}=0$, and reaches IL_{MAX} .

Step 2: While Pch Tr. is “OFF” and synchronous rectifier Nch Tr. is “ON”, L tries to maintain $IL=IL_{MAX}$, so $IL=i2$ flows into L .

Step 3: $IL=i2$ decreases gradually and reaches $IL=IL_{MIN}=0$ after the time while Pch Tr. is “OFF” and $IL=IL_{MIN}=0$ (t_{OPEN}). Then, synchronous rectifier Nch Tr. turns “OFF”. Provided that in the continuous mode, next cycle starts before $IL=IL_{MIN}=0$ because the time while Pch Tr. is “OFF” (t_{OFF}) is not enough. In this case, IL value increases from this $IL_{MIN} (>0)$.

In the case of PWM mode, V_{OUT} is maintained by controlling t_{ON} . During PWM mode, the oscillator frequency (f_{osc}) is being maintained constant.

As shown in Diag. 2, while the step-down operation is constant, the minimum inductor current (IL_{MIN}) and the maximum inductor current (IL_{MAX}) when Pch Tr. is “ON” would be same as the maximum and the minimum inductor currents when Pch Tr. is “OFF”.

The current differential between IL_{MAX} and IL_{MIN} is described as ΔI .

$$\Delta I = IL_{MAX} - IL_{MIN} = V_{OUT} \times t_{OPEN} / L = (V_{IN} - V_{OUT}) \times t_{ON} / L \quad \text{Equation 1}$$

However,

$$T = 1 / f_{osc} = t_{ON} + t_{OFF}$$

$$\text{duty}(\%) = t_{ON} / T \times 100 = t_{ON} \times f_{osc} \times 100$$

$$t_{OPEN} \leq t_{OFF}$$

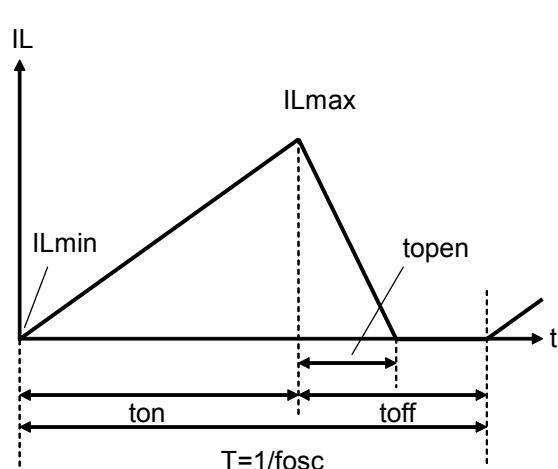
In Equation 1, “ $V_{OUT} \times t_{OPEN} / L$ ” show the amount of current change at “ON”. Also, “ $(V_{IN} - V_{OUT}) \times t_{ON} / L$ ” shows the amount of current change at “OFF”.

- **Discontinuous Mode and Continuous Mode**

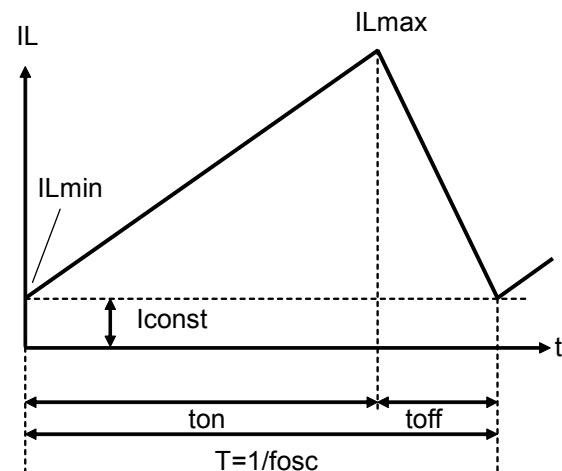
As illustrated in Diag 3., when the output current (I_{OUT}) is relatively small, $t_{OPEN} < t_{OFF}$. In this case, the energy charged into the inductor during t_{ON} will be completely discharged during t_{OFF} , as a result, $I_{L_{MIN}}=0$. This is called discontinuous mode.

When I_{OUT} is gradually increased, eventually $t_{OPEN}=t_{OFF}$ and when I_{OUT} is increased further, eventually $IL_{MIN}>0$. This is called continuous mode.

Diag 3. Discontinuous Mode



Diag 4. Continuous Mode

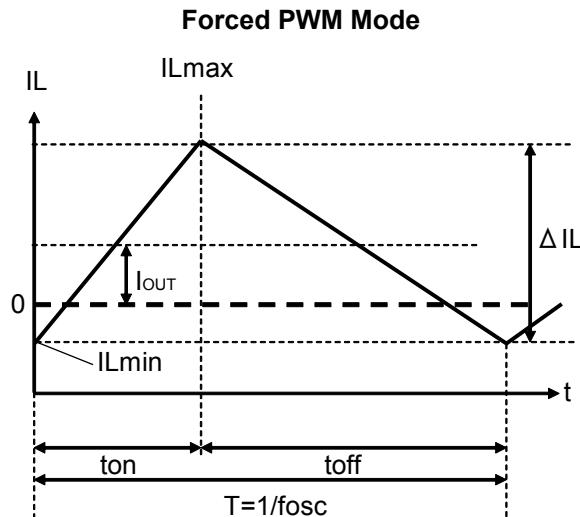


In the continuous mode, the solution of Equation 1 is t_{ONC} :

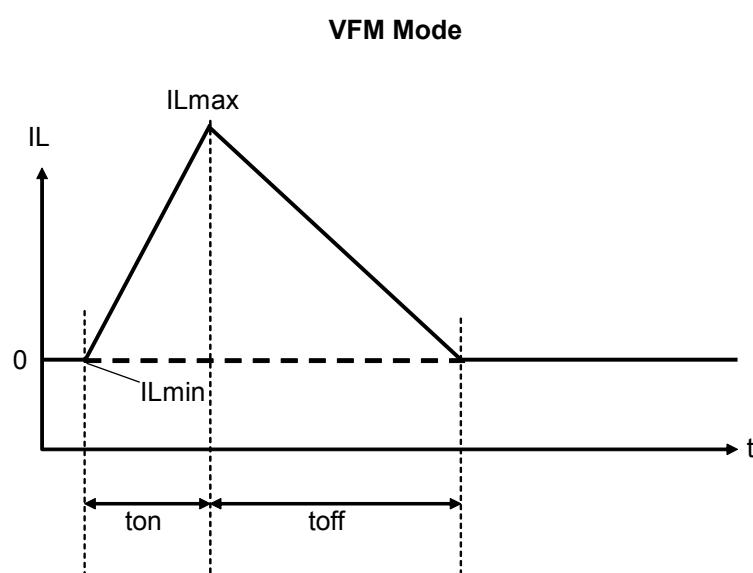
When $t_{ON} < t_{ONC}$, it is discontinuous mode, and when $t_{ON} = t_{ONC}$, it is continuous mode.

● Forced PWM Mode and VFM Mode

By setting the MODE pin to "H", the IC switches the frequency at the fixed rate to reduce noise even when the output load is light. Therefore, when I_{OUT} is $\Delta IL/2$ or less, IL_{MIN} becomes less than 0. That is, the accumulated electricity in CL is discharged through the IC side while IL is increasing from IL_{MIN} to 0 during t_{ON} time, and also while IL is decreasing from 0 to IL_{MIN} during t_{OFF} time.



By setting the MODE pin to "L", in low output current, the IC automatically switches into VFM mode in order to achieve high efficiency. In VFM mode, t_{ON} is forced to end when the inductor current reaches the pre-set IL_{MAX} . With RP550K, IL_{MAX} in the VFM mode is typically set to 280mA. When t_{ON} reaches 1.5 times of $T=1/f_{osc}$, t_{ON} will be forced to end even if the inductor current is not reached IL_{MAX} .



● Output Current and Selection of External Components

The following equations explain the relationship between output current and peripheral components used in the diagram in "TYPICAL APPLICATIONS".

Ripple Current P-P value is described as I_{RP} , ON resistance of Pch Tr. is described as R_{ONP} , ON resistance of Nch Tr. is described as R_{ONN} , and DC resistor of the inductor is described as R_L .

First, when Pch Tr. is "ON", the following equation is satisfied.

$$V_{IN} = V_{OUT} + (R_{ONP} + R_L) \times I_{OUT} + L \times I_{RP} / t_{on} \dots \text{Equation 3}$$

Second, when Pch Tr. is "OFF" (Nch Tr. is "ON"), the following equation is satisfied.

$$L \times I_{RP} / t_{off} = R_{ONN} \times I_{OUT} + V_{OUT} + R_L \times I_{OUT} \dots \text{Equation 4}$$

Put Equation 4 into Equation 3 to solve ON duty of Pch Tr. ($D_{ON} = t_{on} / (t_{off} + t_{on})$):

$$D_{ON} = (V_{OUT} + R_{ONN} \times I_{OUT} + R_L \times I_{OUT}) / (V_{IN} + R_{ONN} \times I_{OUT} - R_{ONP} \times I_{OUT}) \dots \text{Equation 5}$$

Ripple Current is described as follows:

$$I_{RP} = (V_{IN} - V_{OUT} - R_{ONP} \times I_{OUT} - R_L \times I_{OUT}) \times D_{ON} / f_{osc} / L \dots \text{Equation 6}$$

Peak current that flows through L, and L_X Tr. is described as follows:

$$I_{LXmax} = I_{OUT} + I_{RP} / 2 \dots \text{Equation 7}$$

- ★ Please consider I_{LXmax} when setting conditions of input and output, as well as selecting the external components.
- ★ The above calculation formulas are based on the ideal operation of the ICs in continuous mode.

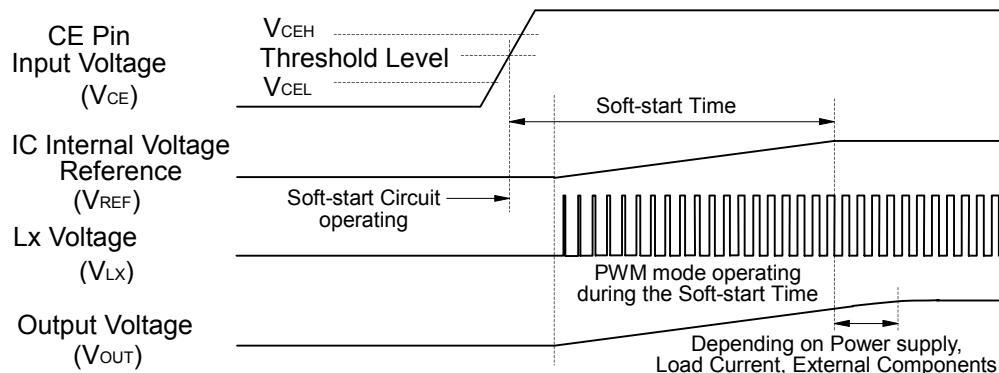
TIMING CHART

(1) Soft Start Time

● Starting-up with CE Pin

The IC starts to operate when the CE pin voltage (V_{CE}) exceed the threshold voltage. The threshold voltage is preset between CE "H" input voltage (V_{CEH}) and CE "L" input voltage (V_{CEL}).

After the start-up of the IC, soft-start circuit starts to operate. Then, after a certain period of time, the reference voltage (V_{REF}) in the IC gradually increases up to the specified value.

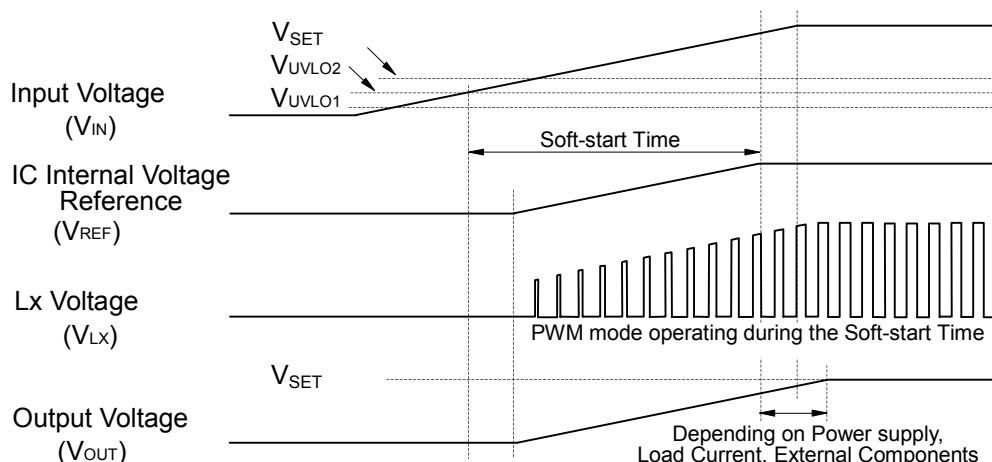


Soft-start time starts when soft-start circuit activates, and ends when the reference voltage reaches the specified voltage.

- ★ Soft start time is not always equal to the turn-on speed of the step-down DC/DC converter. Please note that the turn-on speed could be affected by the power supply capacity, the output current, the inductance value and the C_{OUT} value.

● Starting-up with Power Supply

After the power-on, the IC starts to operate when V_{IN} exceed the UVLO released voltage (V_{UVLO2}). Soft-start circuit starts to operate and then after a certain period of time, V_{REF} in the IC gradually increases up to the specified value. Soft-start time starts when soft-start circuit activates, and ends when V_{REF} reaches the specified voltage.



Soft-start time starts when soft-start circuit activates, and ends when the reference voltage reaches the specified voltage.

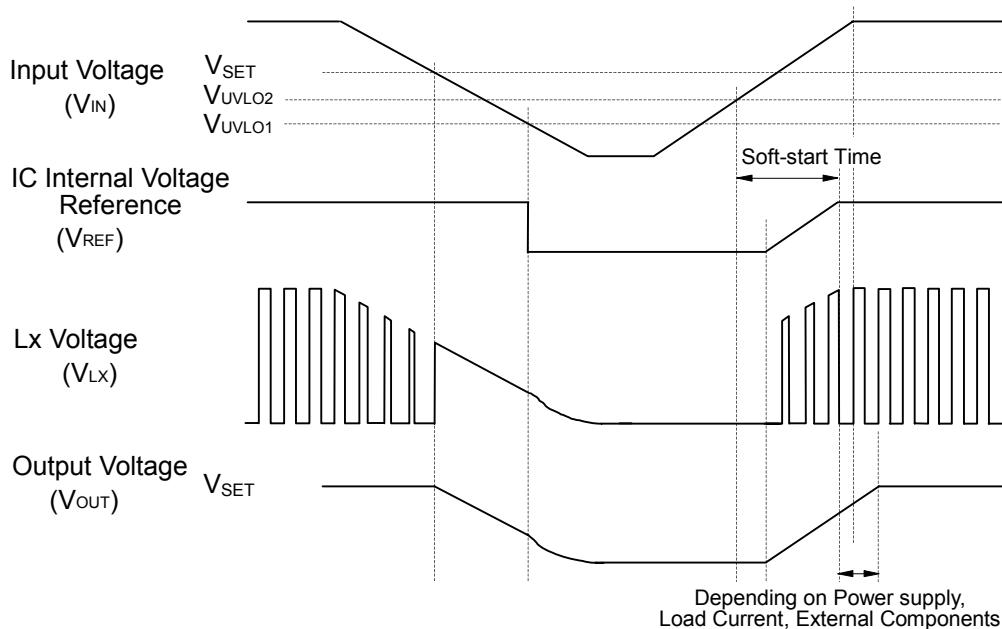
- ★ Please note that the turn-on speed of V_{OUT} could be affected by the power supply capacity, the output current, the inductance value, the C_{OUT} value and the turn-on speed of V_{IN} determined by C_{IN} .

(2) Under Voltage Lockout (UVLO) Circuit

If V_{IN} becomes lower than the setting voltage (V_{SET}), the step-down DC/DC converter stops the switching operation and ON duty becomes 100%, and then V_{OUT} gradually drops according to V_{IN} .

If the V_{IN} drops more and becomes lower than the UVLO detector threshold (V_{UVLO1}), the UVLO circuit (U_{UVLO}) starts to operate, V_{REF} stops, and Pch and Nch built-in switch transistors turn “OFF”. As a result, V_{OUT} drops according to the C_{OUT} capacitance value and the load.

To restart the operation, V_{IN} needs to be higher than V_{UVLO2} . The timing chart below shows the voltage shifts of V_{REF} , V_{LX} and V_{OUT} when V_{IN} value is varied.



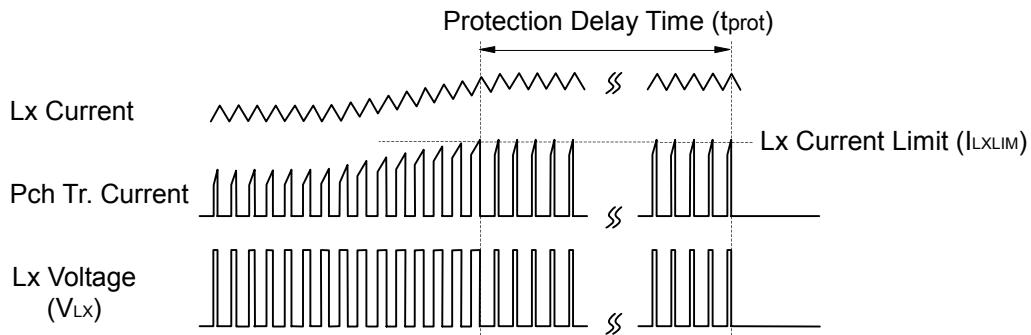
- ★ Falling edge (operating) and rising edge (releasing) waveforms of V_{OUT} could be affected by the initial voltage of C_{OUT} and the output current of V_{OUT} .

(3) Over Current Protection Circuit, Latch Type Protection Circuit

Over current protection circuit supervises the inductor peak current (the peak current flowing through Pch Tr.) in each switching cycle, and if the current exceeds the L_x current limit (I_{LXLIM}), it turns off Pch Tr. I_{LXLIM} of the RP550K001A is set to Typ.1700mA.

Latch type protection circuit latches the built-in driver to the OFF state and stops the operation of the step-down DC/DC converter if the over current status continues or V_{OUT} continues being the half of the setting voltage for equal or longer than protection delay time ($tprot$).

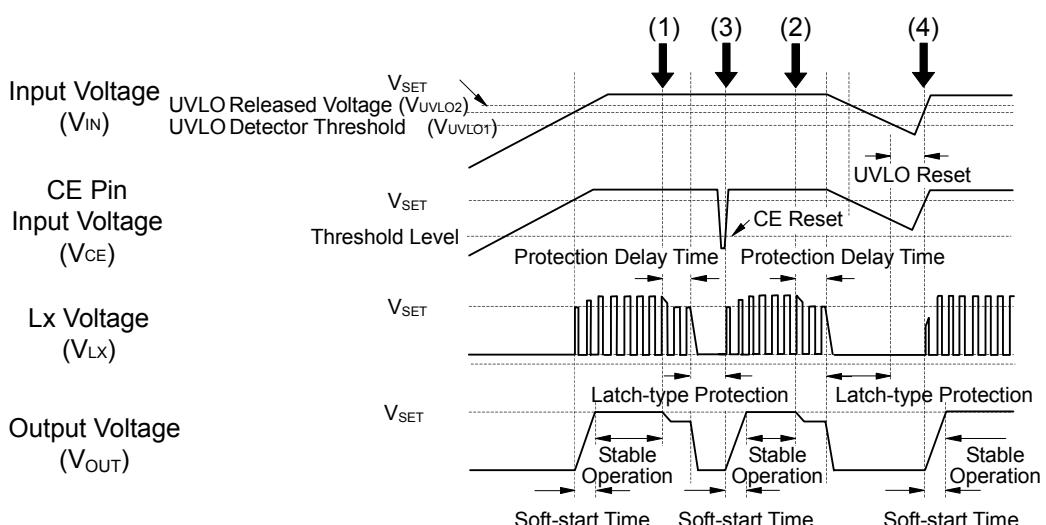
Note: I_{LXLIM} and $tprot$ could be easily affected by self-heating or ambient environment. If the V_{IN} drops dramatically or becomes unstable due to short-circuit, protection operation and $tprot$ could be affected.



To release the latch type protection circuit, restart the IC by inputting "L" signal to CE pin, or restart the IC with power-on or make the supply voltage lower than V_{UVLO1} .

The timing chart below shows the voltage shifts of V_{LX} and V_{OUT} when the IC status is changed by the following orders: V_{IN} and V_{CE} rising → stable operation → high load → CE reset → stable operation → high load → V_{IN} falling → V_{IN} recovering (UVLO reset) → stable operation.

- (1)(2) If the large current flows through the circuit or the IC goes into low V_{OUT} condition due to short-circuit or other reasons, the latch type protection circuit latches the built-in driver to "OFF" state after $tprot$. Then, V_{LX} becomes "L" and V_{OUT} turns "OFF".
- (3) The latch type protection circuit is released by CE reset, which puts the IC into "L" once with the CE pin and back into "H".
- (4) The latch type protection circuit is released by UVLO reset, which makes V_{IN} lower than V_{UVLO1} .

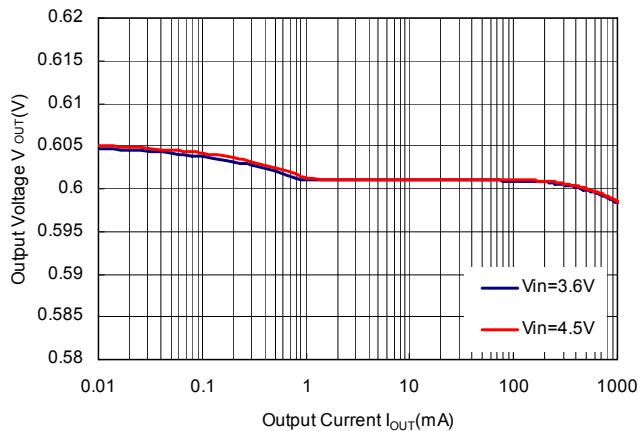


CHARACTERISTICS

1) Output Voltage vs. Output Current

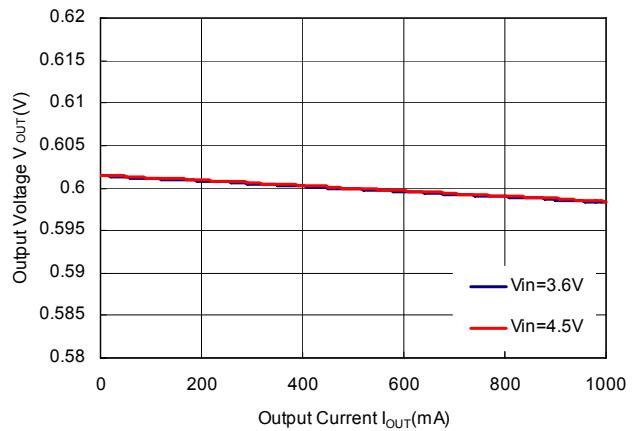
RP550K001A $V_{OUT}=0.6V$

MODE="L" PWM/VFM Auto Switching Control



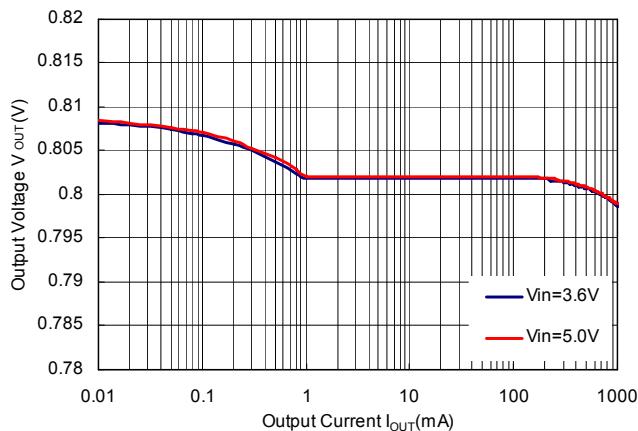
RP550K001A $V_{OUT}=0.6V$

MODE="H" Forced PWM Control



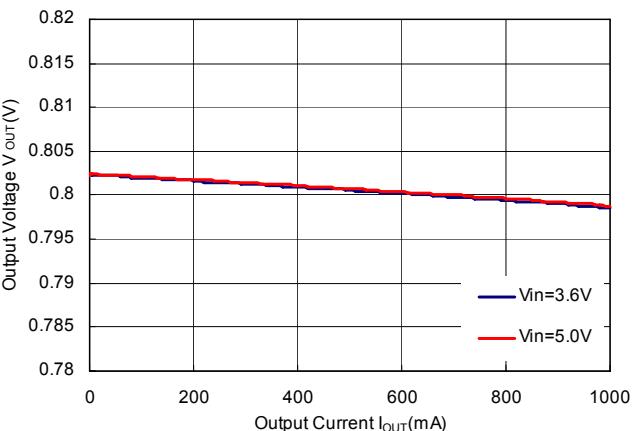
RP550K001A $V_{OUT}=0.8V$

MODE="L" PWM/VFM Auto Switching Control



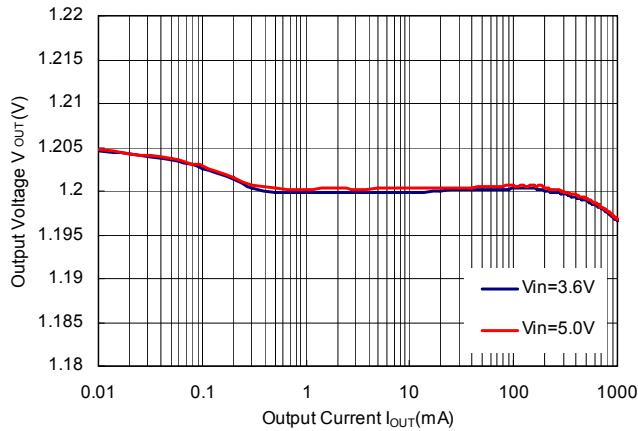
RP550K001A $V_{OUT}=0.8V$

MODE="H" Forced PWM Control



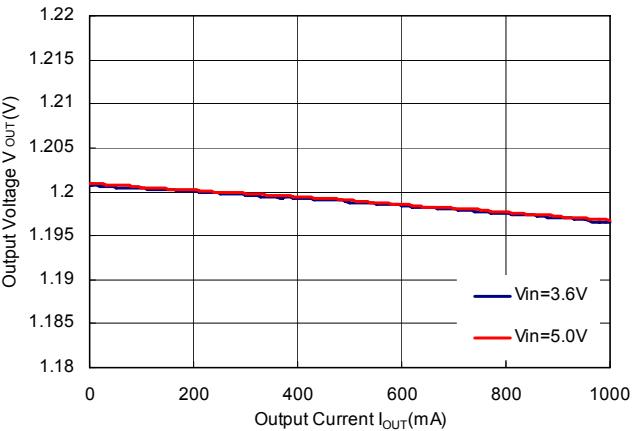
RP550K001A $V_{OUT}=1.2V$

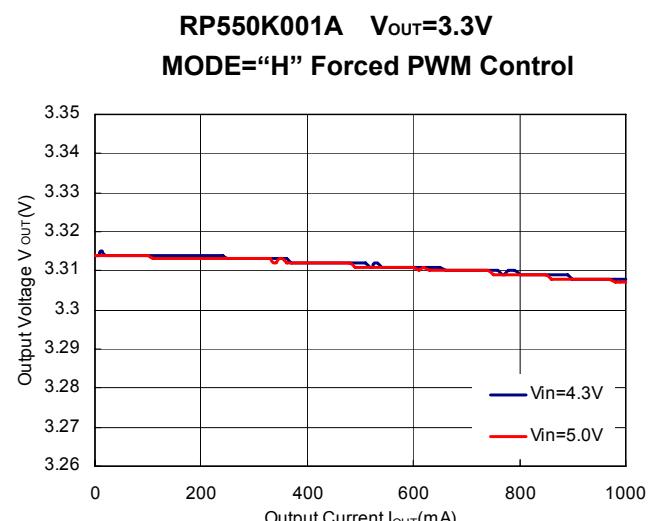
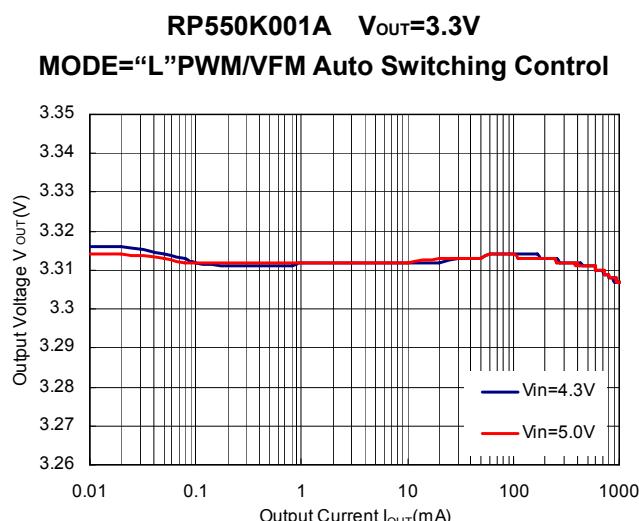
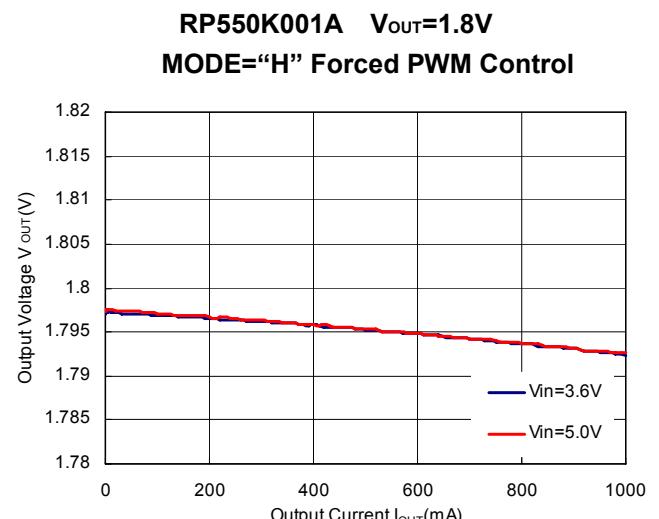
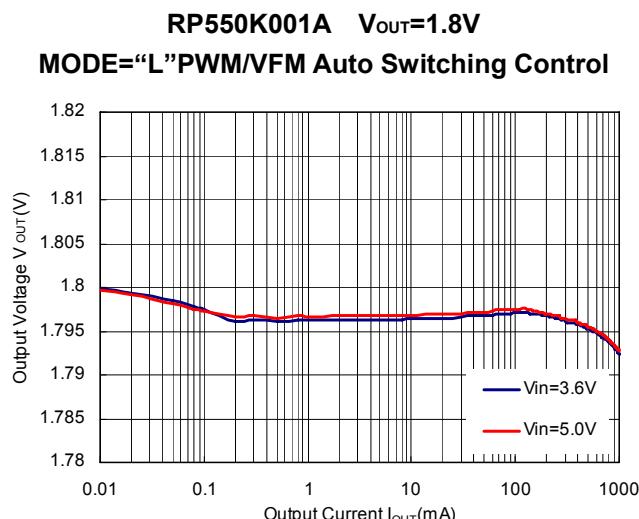
MODE="L" PWM/VFM Auto Switching Control



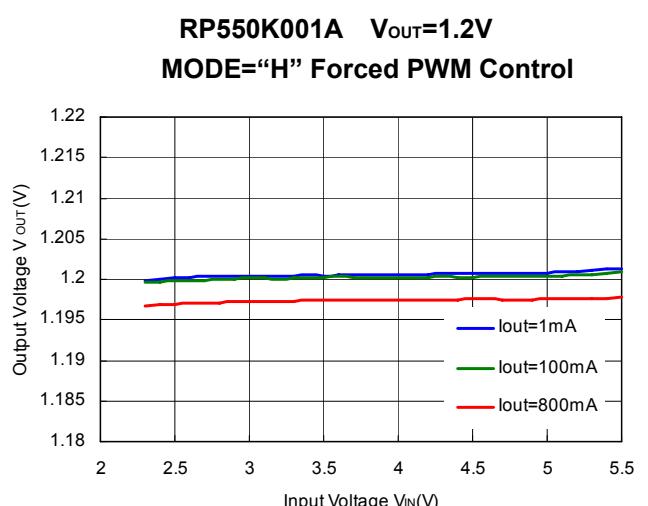
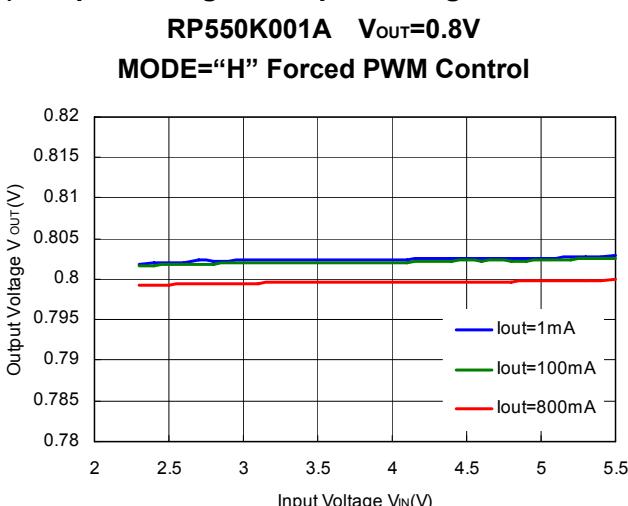
RP550K001A $V_{OUT}=1.2V$

MODE="H" Forced PWM Control

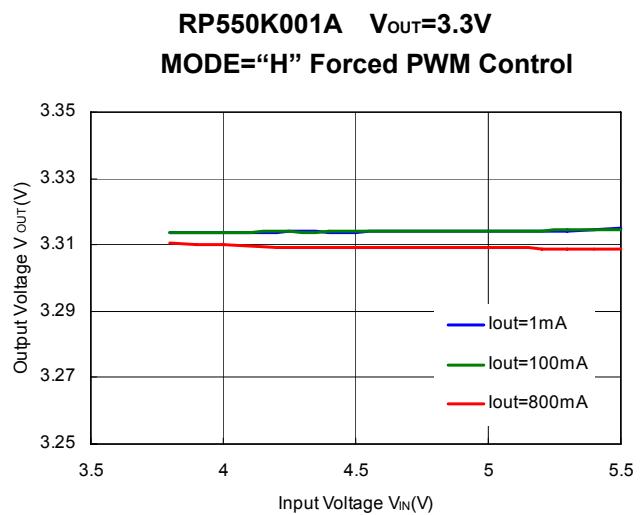
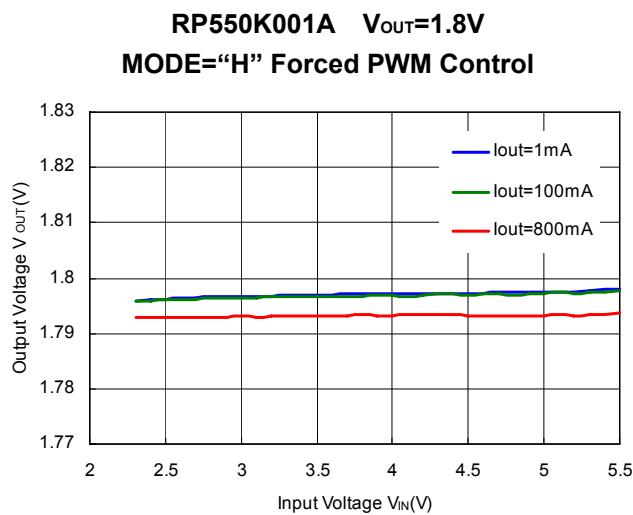




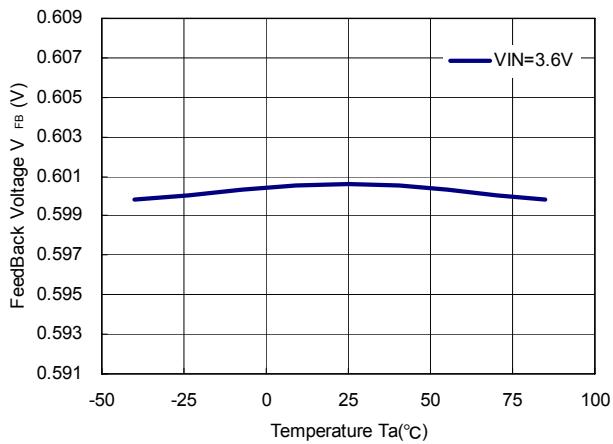
2) Output Voltage vs. Input Voltage



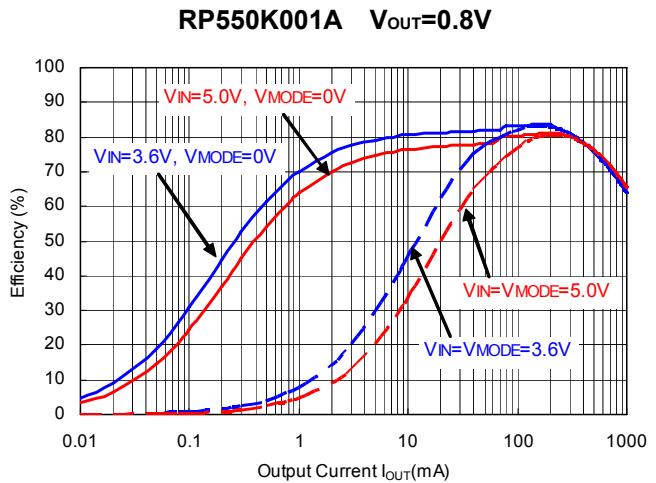
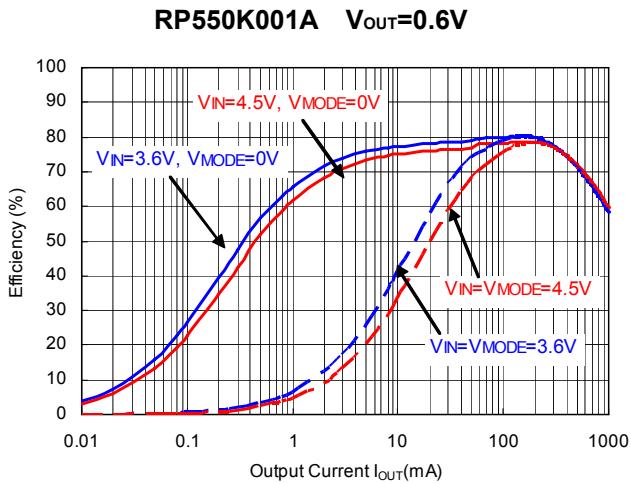
RP550K001A

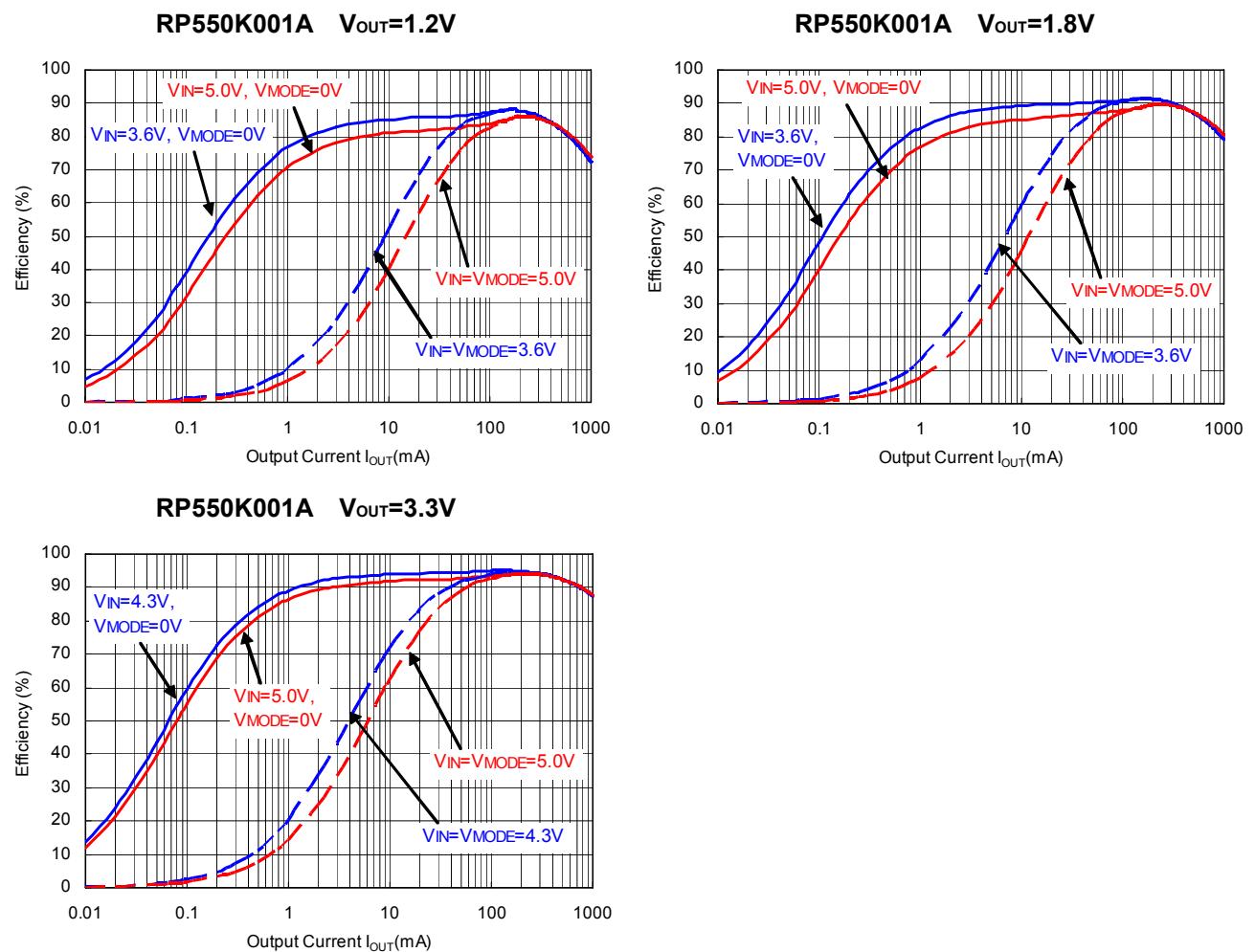


3) Feedback Voltage vs. Ambient Temperature



4) Efficiency vs. Output Current

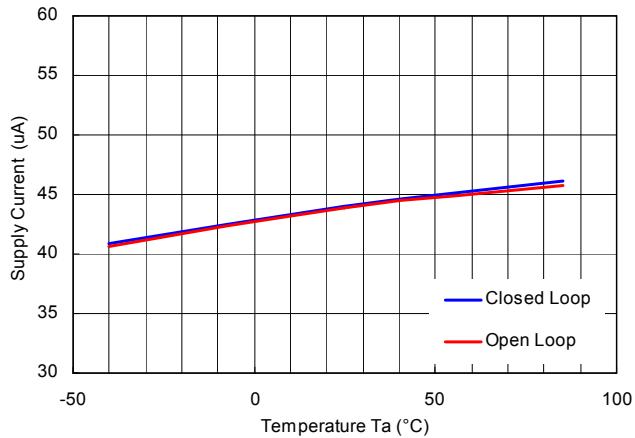




5) Supply Current vs. Ambient Temperature

RP550K001A $V_{OUT}=1.8V$ ($V_{IN}=5.5V$)

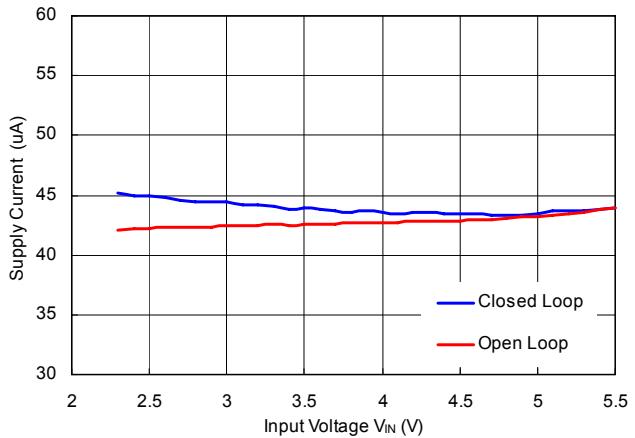
MODE="L" PWM/VFM Auto Switching Control



6) Supply Current vs. Input Voltage

RP550K001A $V_{OUT}=1.8V$

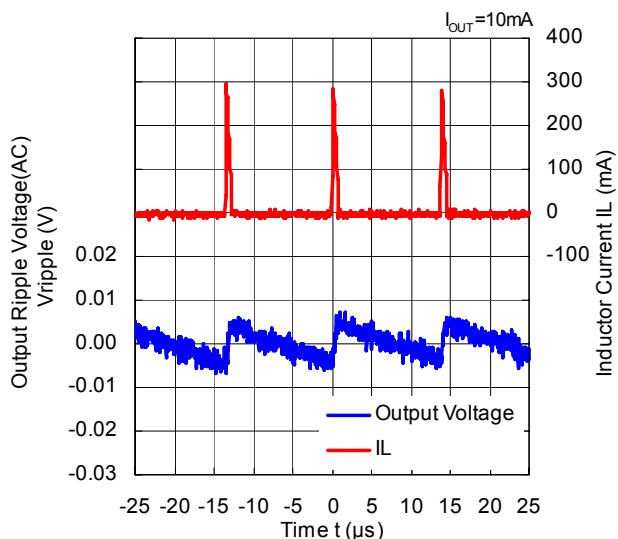
MODE="L" PWM/VFM Auto Switching Control



7) Output Voltage Waveform

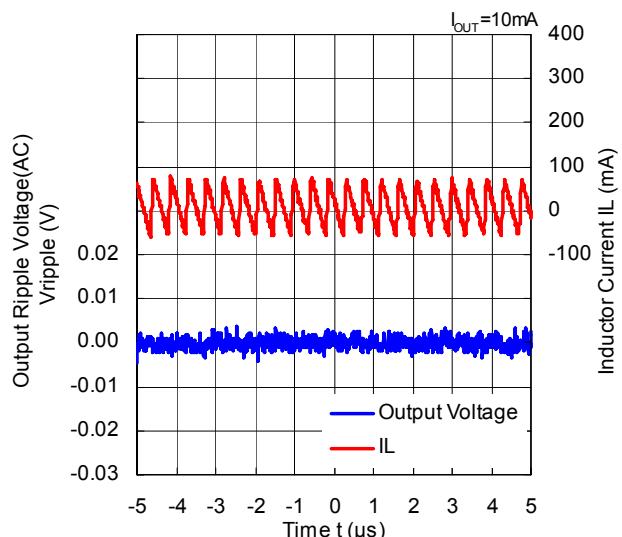
RP550K001A $V_{OUT}=0.6V$ ($V_{IN}=3.6V$)

MODE="L" PWM/VFM Auto Switching Control

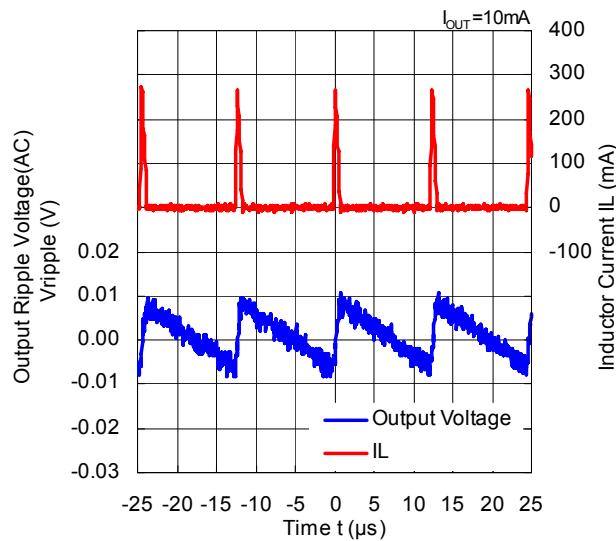


RP550K001A $V_{OUT}=0.6V$ ($V_{IN}=3.6V$)

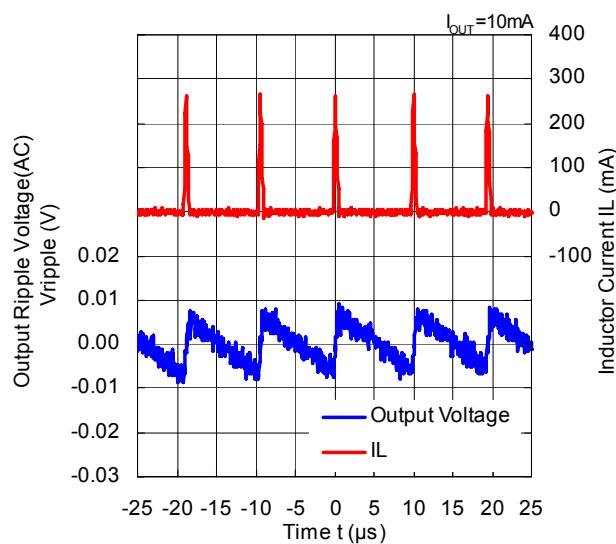
MODE="H" Forced PWM Control



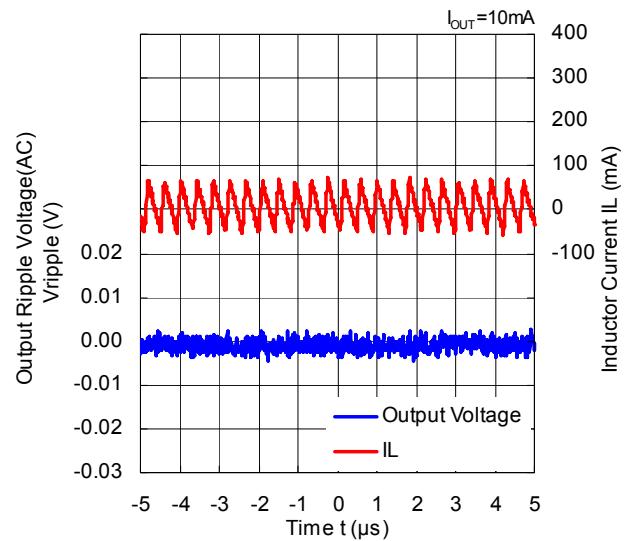
RP550K001A $V_{OUT}=0.8V(V_{IN}=3.6V)$
MODE="L" PWM/VFM Auto Switching Control



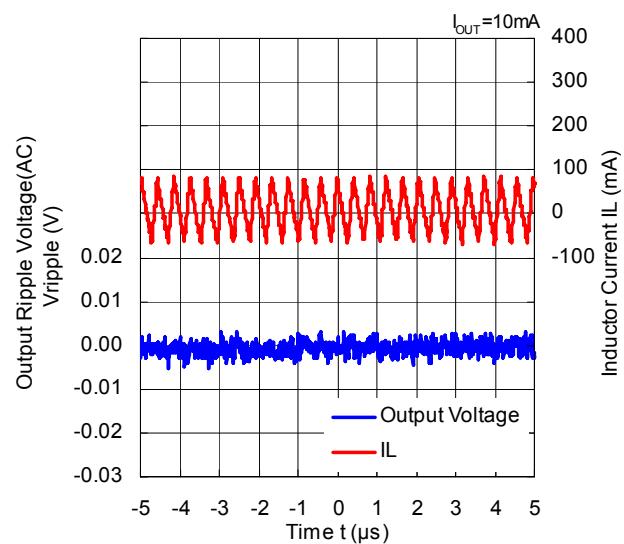
RP550K001A $V_{OUT}=1.2V(V_{IN}=3.6V)$
MODE="L" PWM/VFM Auto Switching Control



RP550K001A $V_{OUT}=0.8V(V_{IN}=3.6V)$
MODE="H" Forced PWM Control

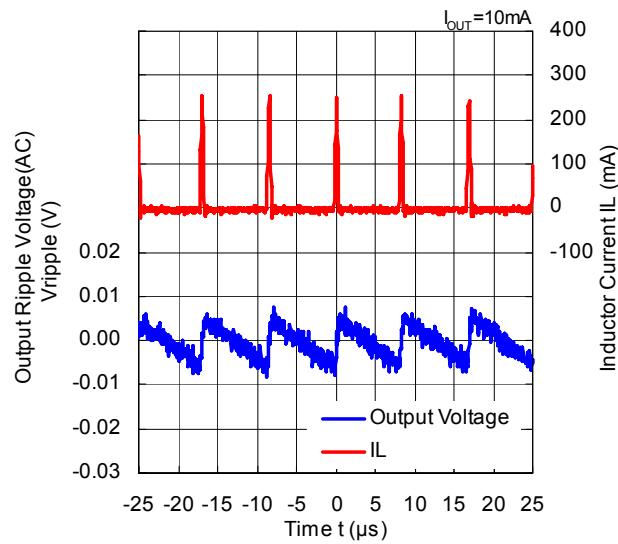


RP550K001A $V_{OUT}=1.2V(V_{IN}=3.6V)$
MODE="H" Forced PWM Control

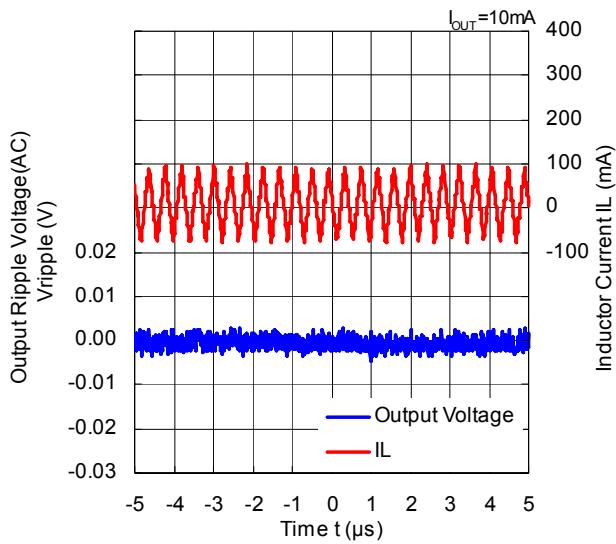


RP550K001A

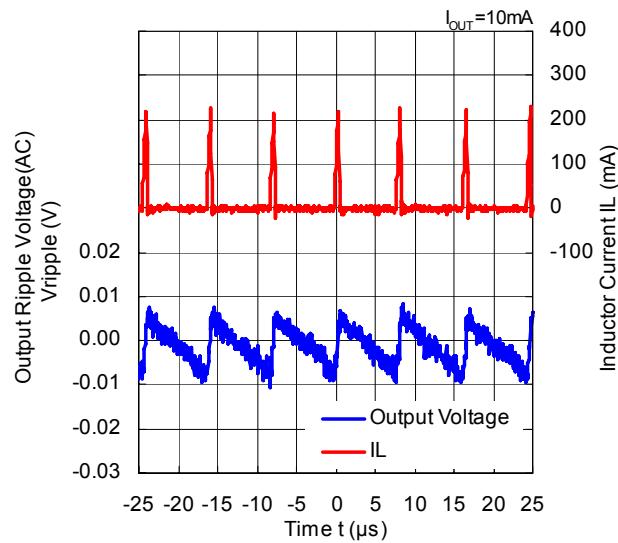
**RP550K001A $V_{OUT}=1.8V(V_{IN}=3.6V)$
MODE="L" PWM/VFM Auto Switching Control**



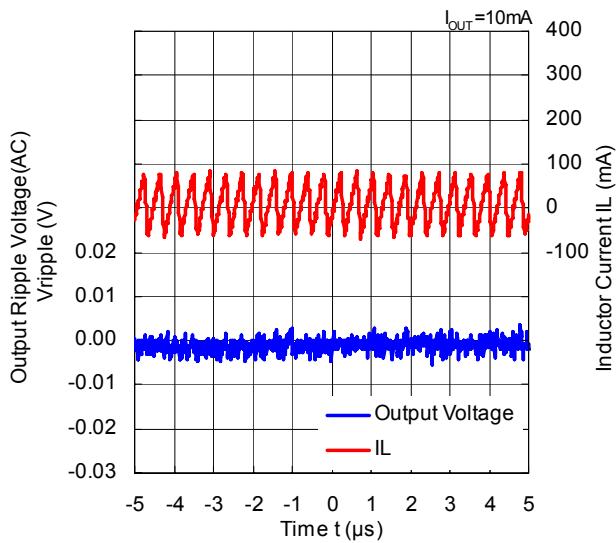
**RP550K001A $V_{OUT}=1.8V(V_{IN}=3.6V)$
MODE="H" Forced PWM Control**



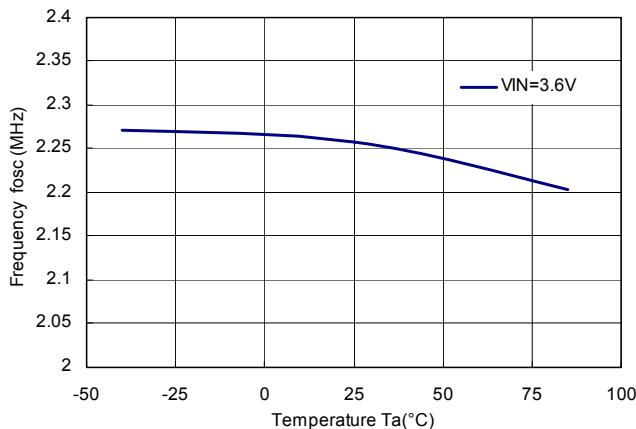
**RP550K001A $V_{OUT}=3.3V(V_{IN}=4.3V)$
MODE="L" PWM/VFM Auto Switching Control**



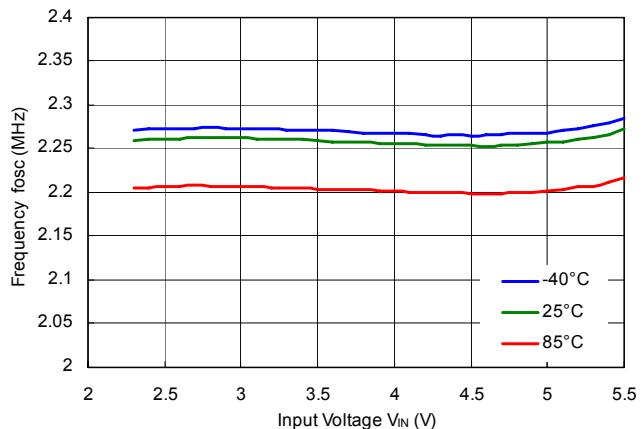
**RP550K001A $V_{OUT}=3.3V(V_{IN}=4.3V)$
MODE="H" Forced PWM Control**



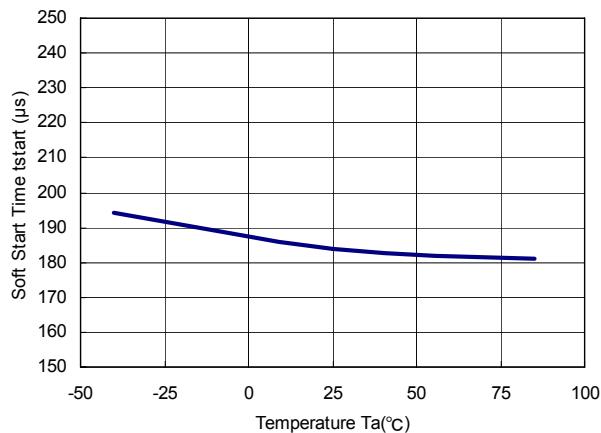
8) Oscillator Frequency vs. Ambient Temperature



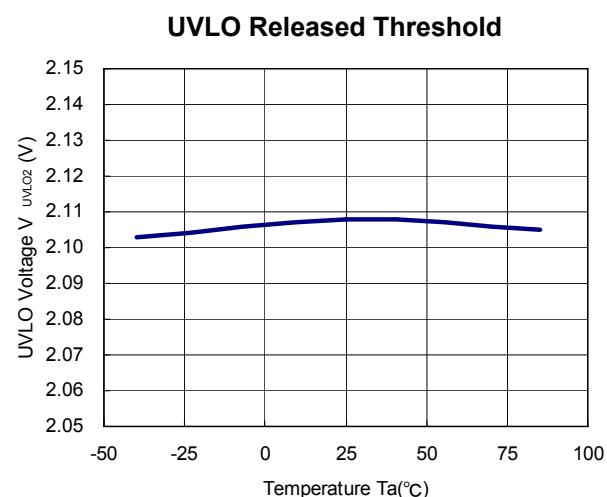
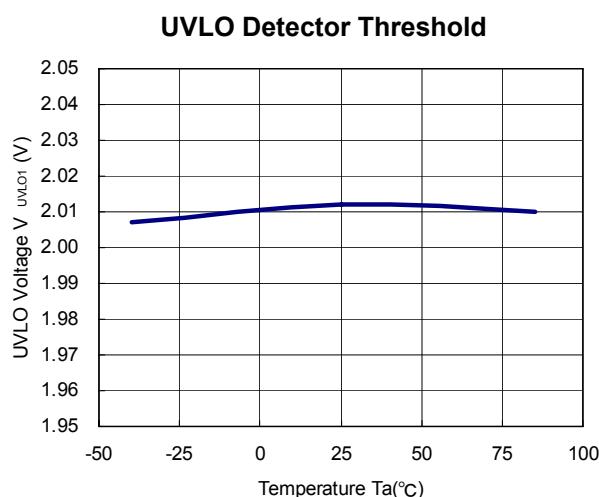
9) Oscillator Frequency vs. Input Voltage

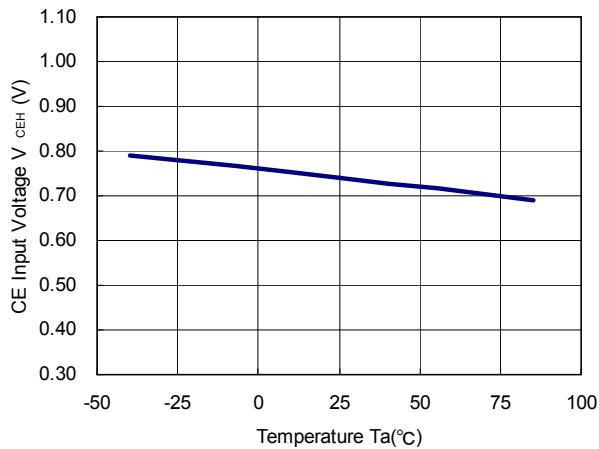
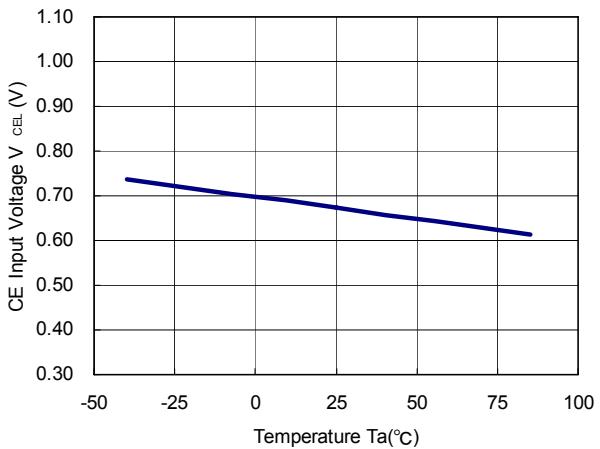
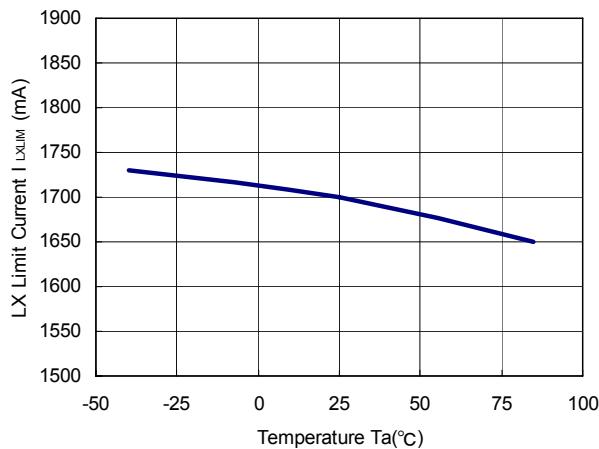
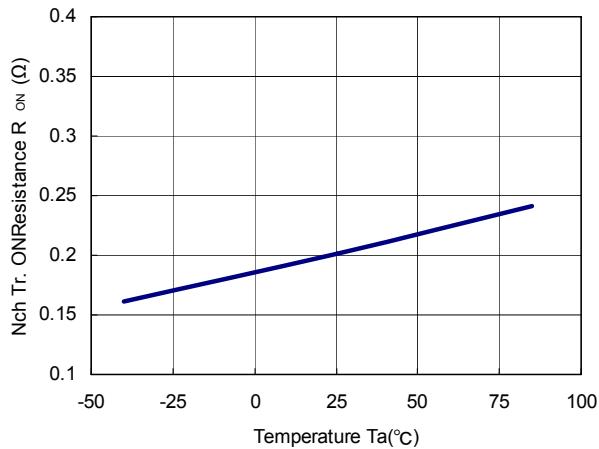
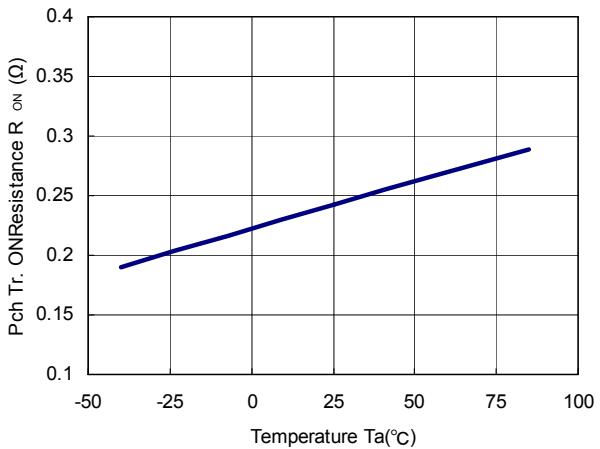


10) Soft-start Time vs. Ambient Temperature



11) UVLO Detector/ Released Threshold vs. Ambient Temperature

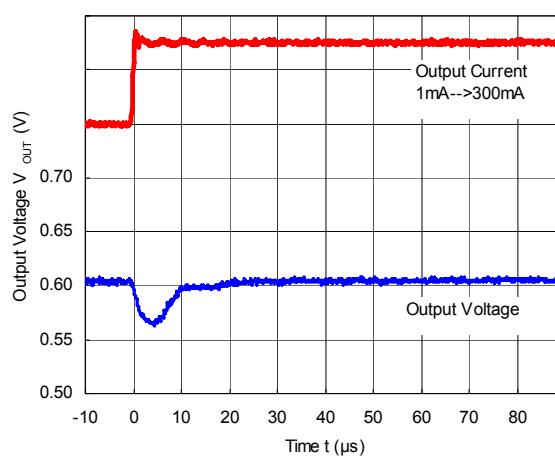


12) CE Input Voltage vs. Ambient Temperature**CE "H" Input Voltage ($V_{IN}=5.5V$)****CE "L" Input Voltage ($V_{IN}=2.3V$)****13) Lx Limit Current vs. Ambient Temperature****14) Nch Transistor ON Resistance vs. Ambient Temperature****15) Pch Transistor ON Resistance vs. Ambient Temperature**

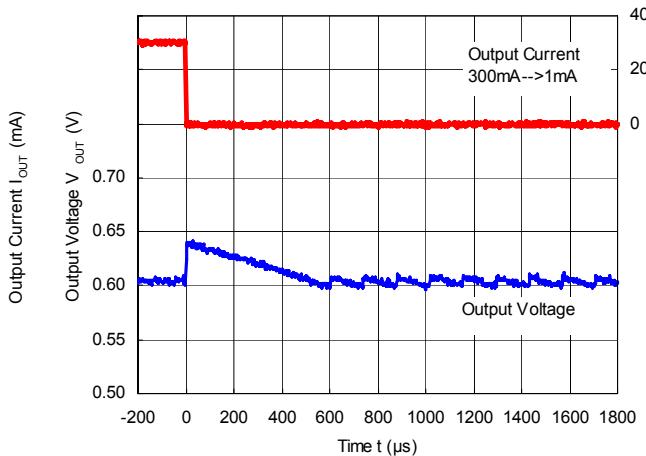
16) Load Transient Response

RP550K001A ($V_{IN}=3.6V$, $V_{OUT}=0.6V$)

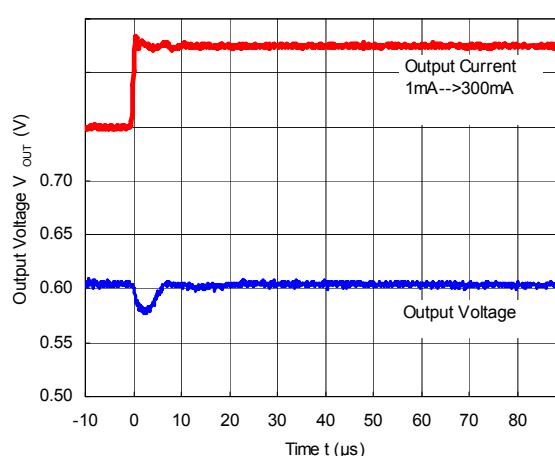
MODE="L" PWM/VFM Auto Switching Control

RP550K001A ($V_{IN}=3.6V$, $V_{OUT}=0.6V$)

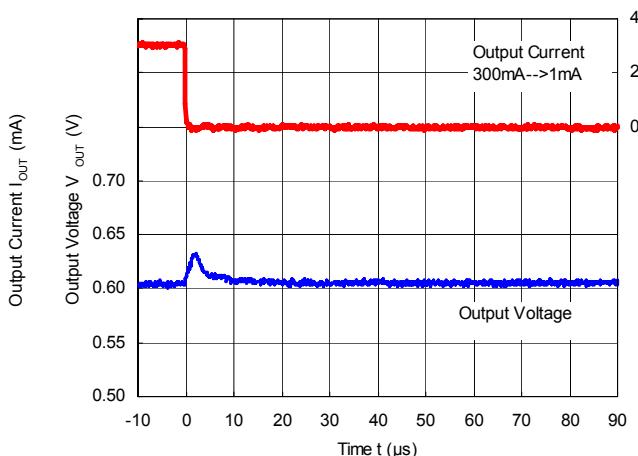
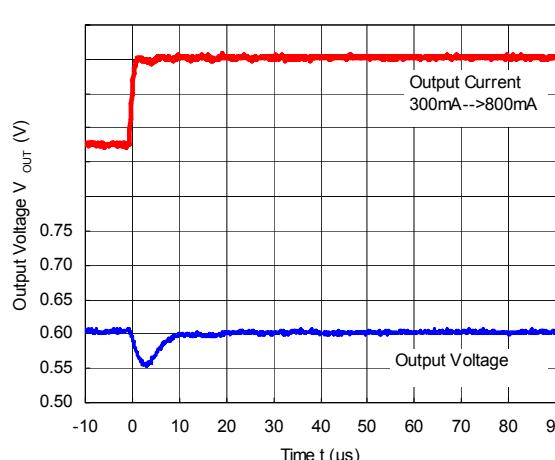
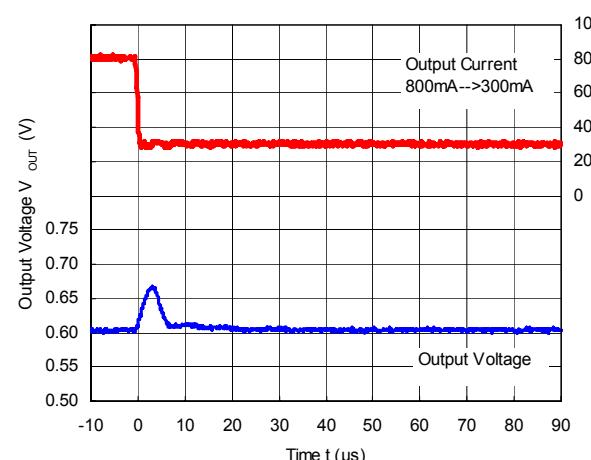
MODE="L" PWM/VFM Auto Switching Control

RP550K001A ($V_{IN}=3.6V$, $V_{OUT}=0.6V$)

MODE="H" Forced PWM Control

RP550K001A ($V_{IN}=3.6V$, $V_{OUT}=0.6V$)

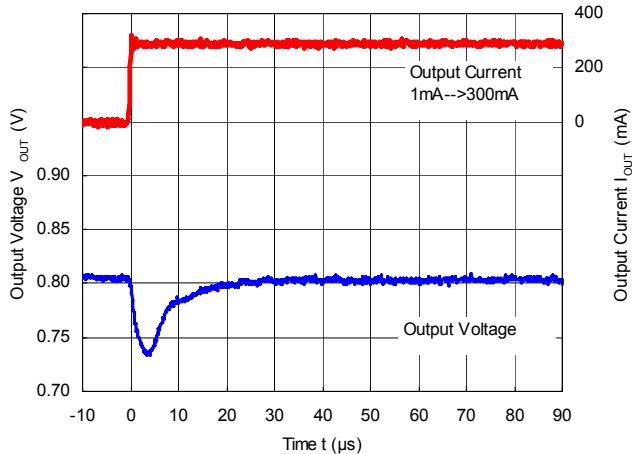
MODE="H" Forced PWM Control

RP550K001A ($V_{IN}=3.6V$, $V_{OUT}=0.6V$)RP550K001A ($V_{IN}=3.6V$, $V_{OUT}=0.6V$)

RP550K001A

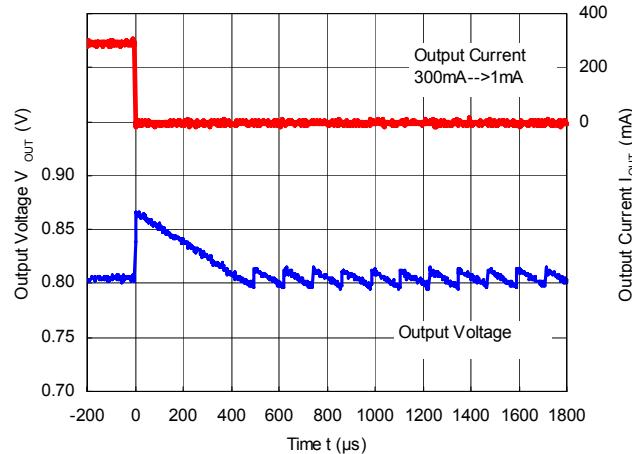
RP550K001A ($V_{IN}=3.6V$, $V_{OUT}=0.8V$)

MODE="L" PWM/VFM Auto Switching Control



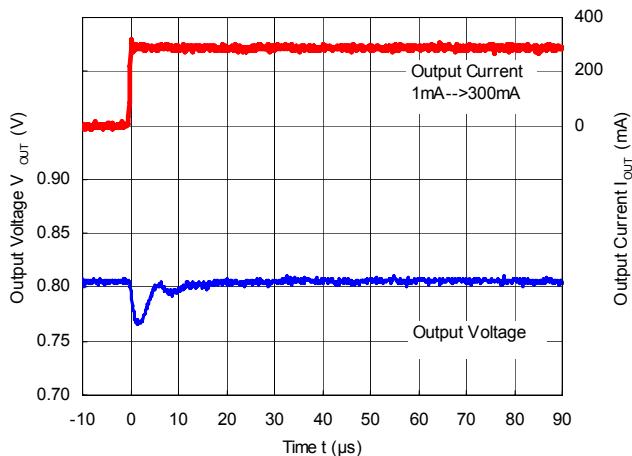
RP550K001A ($V_{IN}=3.6V$, $V_{OUT}=0.8V$)

MODE="L" PWM/VFM Auto Switching Control



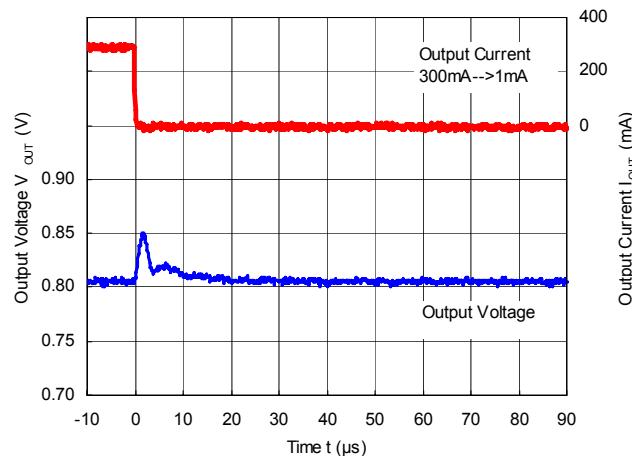
RP550K001A ($V_{IN}=3.6V$, $V_{OUT}=0.8V$)

MODE="H" Forced PWM Control

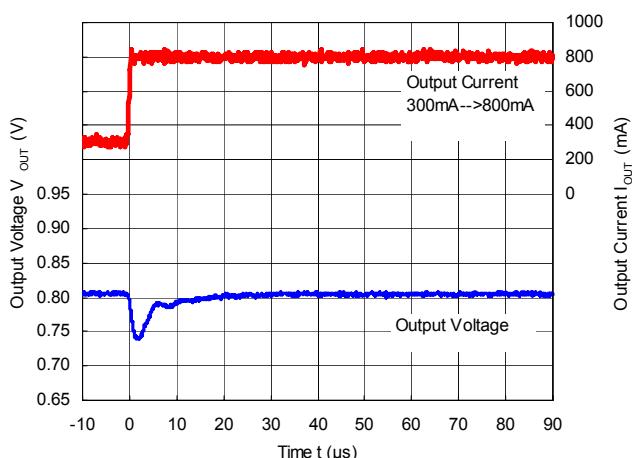


RP550K001A ($V_{IN}=3.6V$, $V_{OUT}=0.8V$)

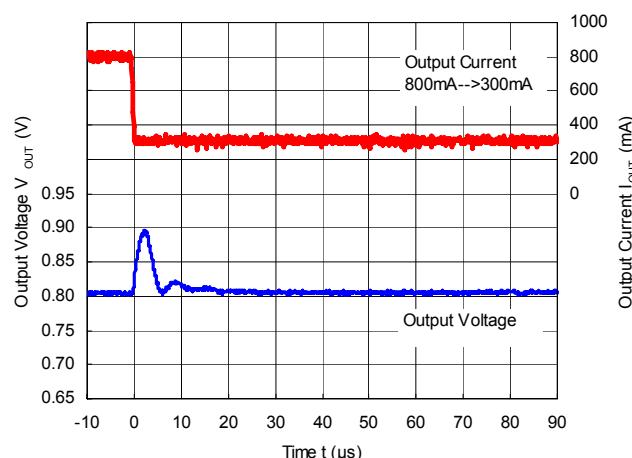
MODE="H" Forced PWM Control



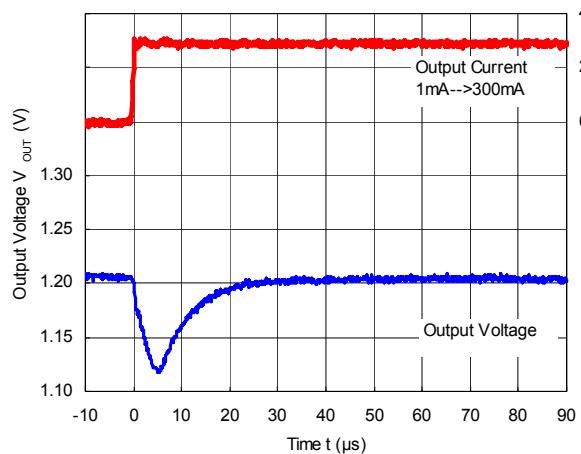
RP550K001A ($V_{IN}=3.6V$, $V_{OUT}=0.8V$)



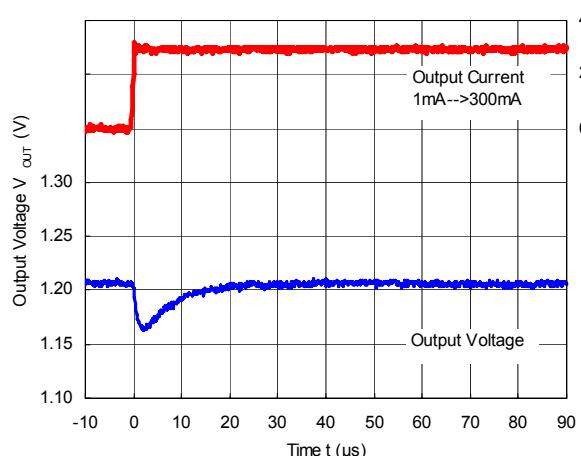
RP550K001A ($V_{IN}=3.6V$, $V_{OUT}=0.8V$)



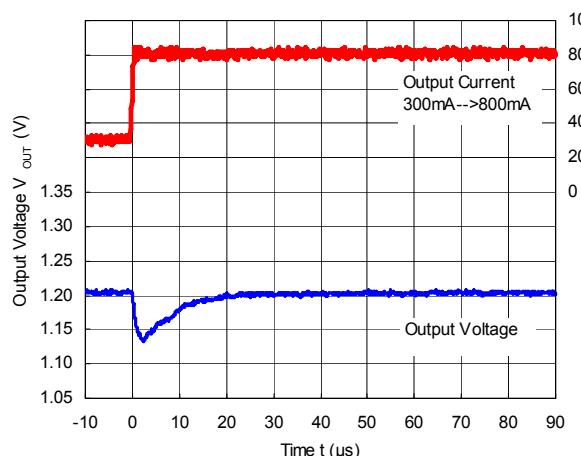
RP550K001A (V_{IN}=3.6V, V_{OUT}=1.2V)
MODE="L" PWM/VFM Auto Switching Control



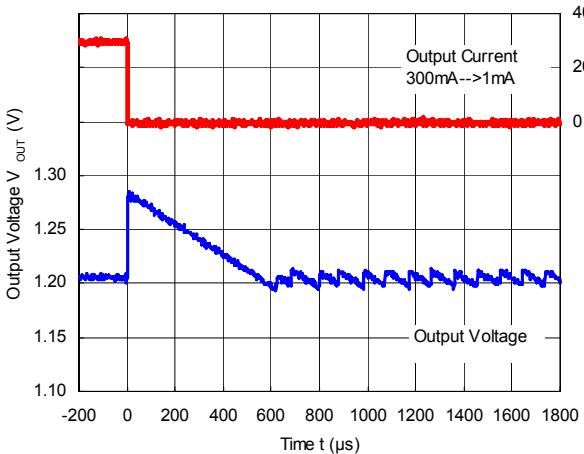
RP550K001A (V_{IN}=3.6V, V_{OUT}=1.2V) MODE="H" Forced PWM Control



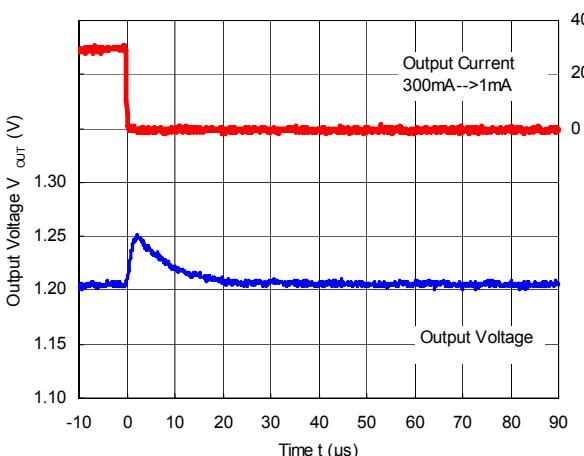
RP550K001A (V_{IN}=3.6V, V_{OUT}=1.2V)



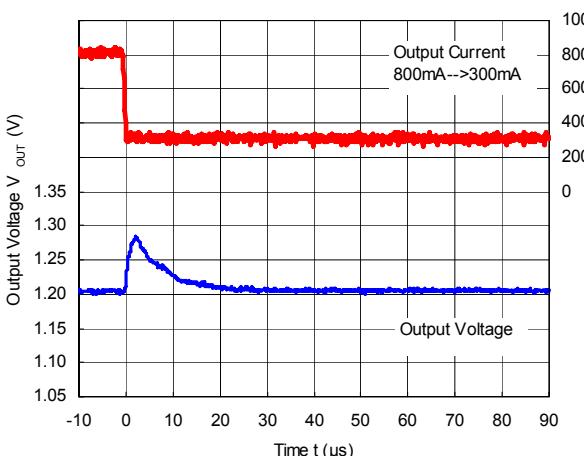
RP550K001A (V_{IN}=3.6V, V_{OUT}=1.2V) MODE="L" PWM/VFM Auto Switching Control



RP550K001A (V_{IN}=3.6V, V_{OUT}=1.2V) MODE="H" Forced PWM Control



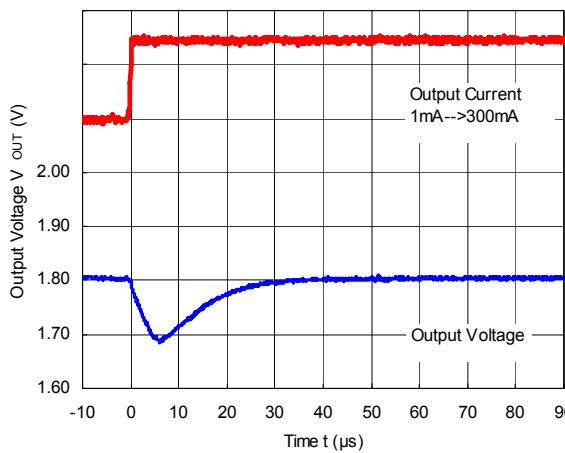
RP550K001A (V_{IN}=3.6V, V_{OUT}=1.2V)



RP550K001A

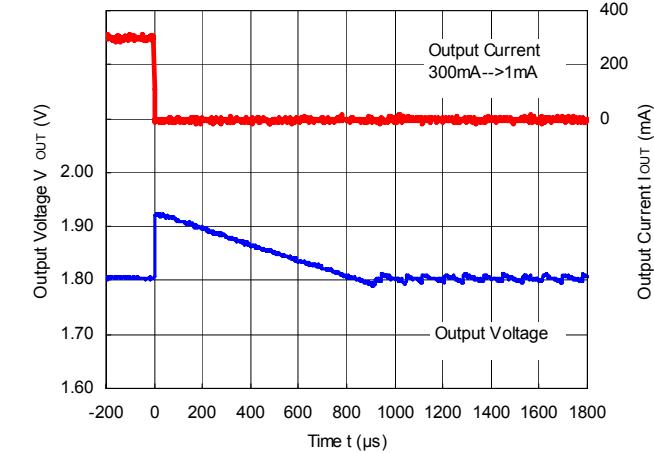
RP550K001A ($V_{IN}=3.6V$, $V_{OUT}=1.8V$)

MODE="L" PWM/VFM Auto Switching Control



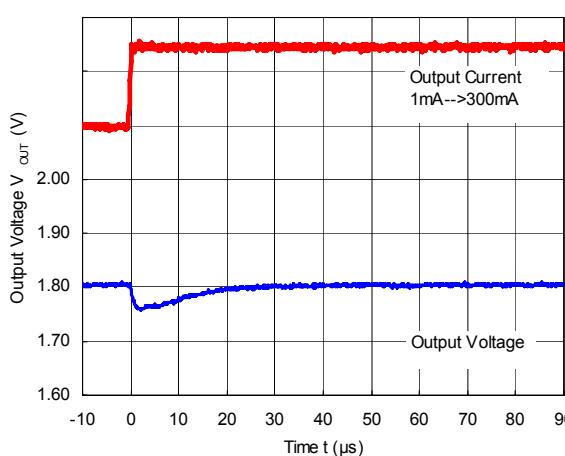
RP550K001A ($V_{IN}=3.6V$, $V_{OUT}=1.8V$)

MODE="L" PWM/VFM Auto Switching Control



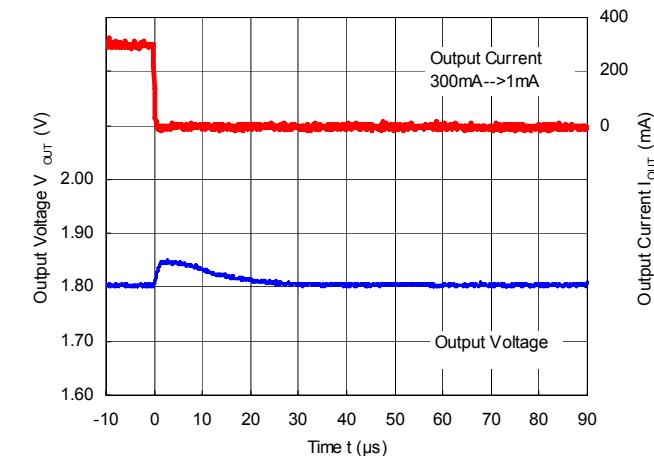
RP550K001A ($V_{IN}=3.6V$, $V_{OUT}=1.8V$)

MODE="H" Forced PWM Control

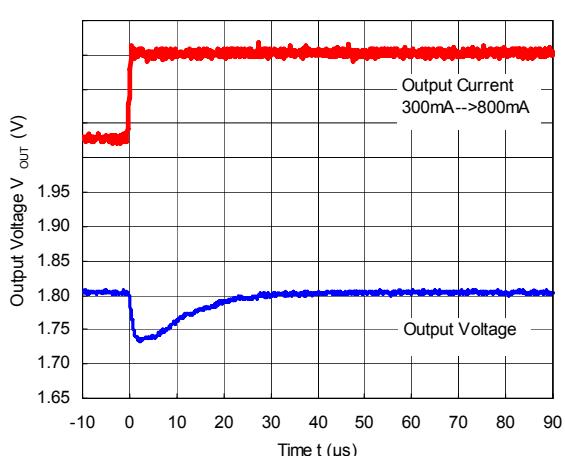


RP550K001A ($V_{IN}=3.6V$, $V_{OUT}=1.8V$)

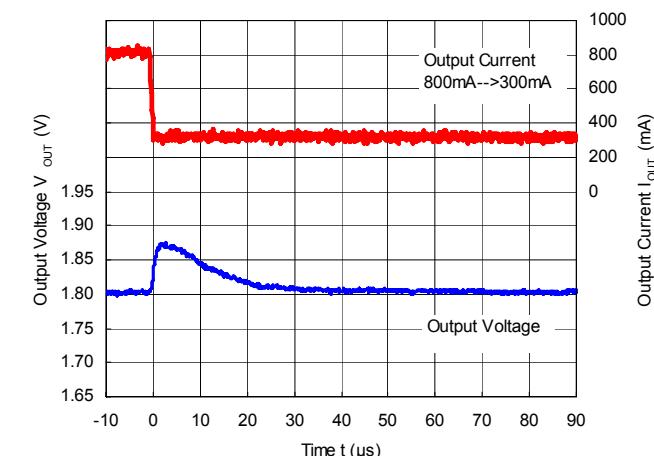
MODE="H" Forced PWM Control



RP550K001A ($V_{IN}=3.6V$, $V_{OUT}=1.8V$)

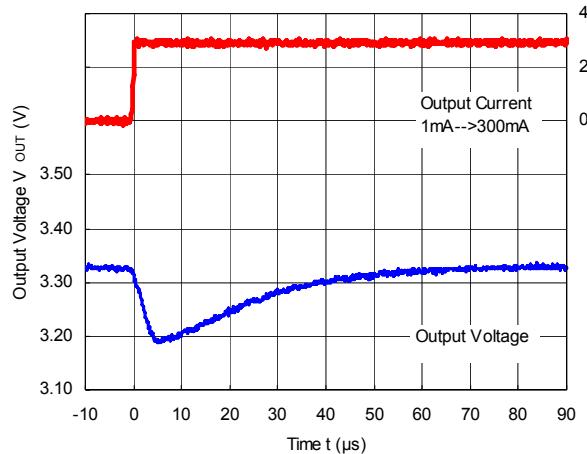


RP550K001A ($V_{IN}=3.6V$, $V_{OUT}=1.8V$)



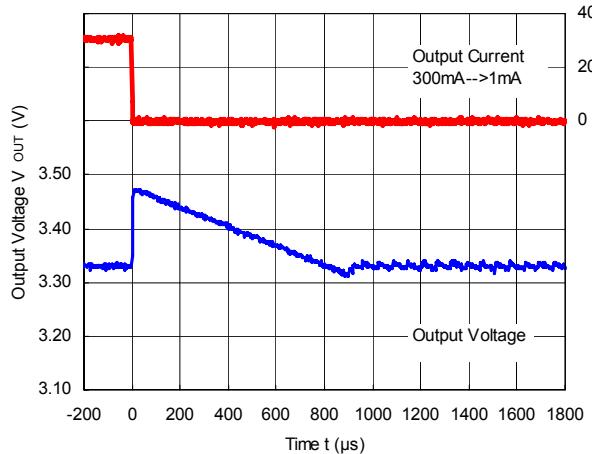
RP550K001A ($V_{IN}=5.0V$, $V_{OUT}=3.3V$)

MODE="L" PWM/VFM Auto Switching Control



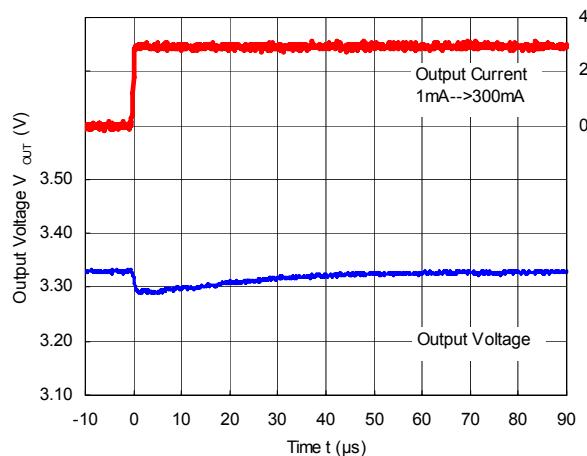
RP550K001A ($V_{IN}=5.0V$, $V_{OUT}=3.3V$)

MODE="L" PWM/VFM Auto Switching Control



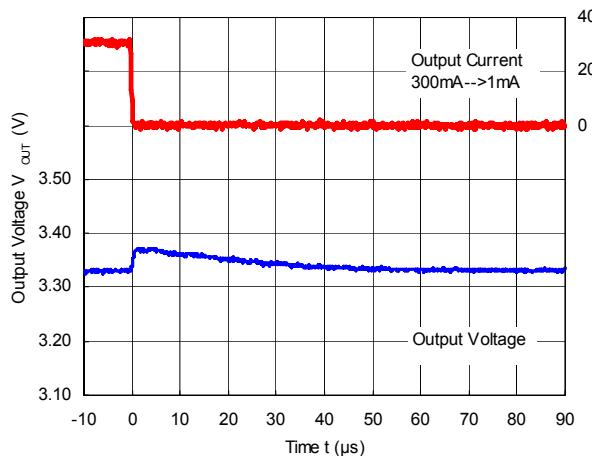
RP550K001A ($V_{IN}=5.0V$, $V_{OUT}=3.3V$)

MODE="H" Forced PWM Control

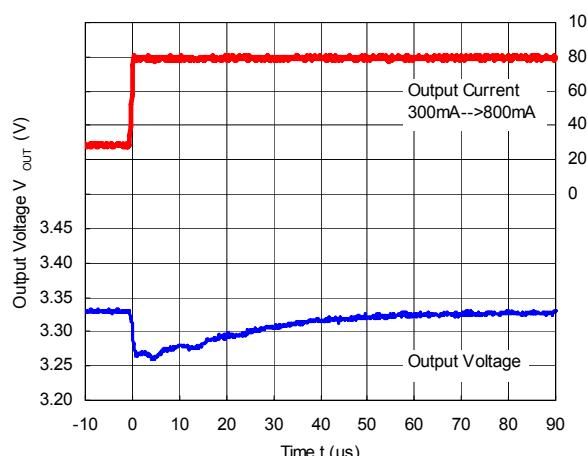


RP550K001A ($V_{IN}=5.0V$, $V_{OUT}=3.3V$)

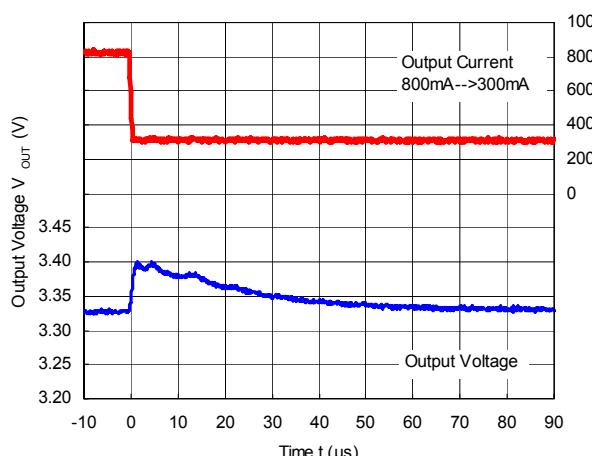
MODE="H" Forced PWM Control



RP550K001A ($V_{IN}=5.0V$, $V_{OUT}=3.3V$)

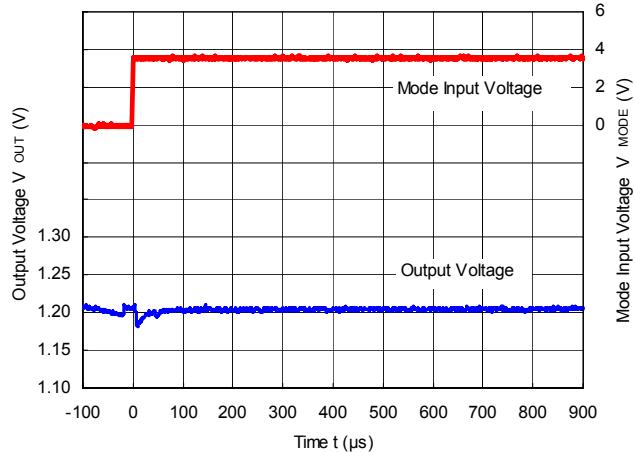


RP550K001A ($V_{IN}=5.0V$, $V_{OUT}=3.3V$)

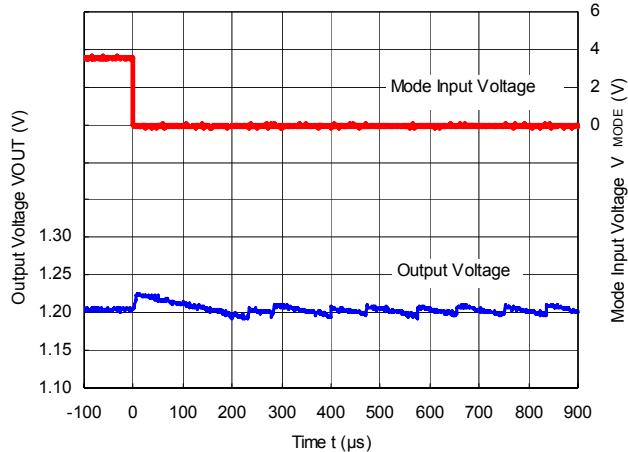


17) Mode Switching Waveform

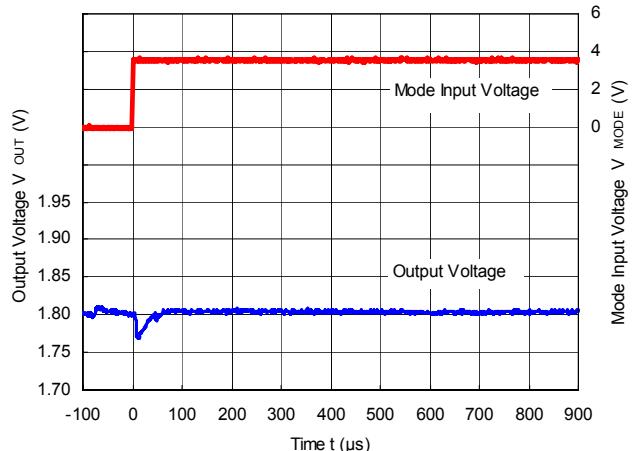
RP550K001A ($V_{IN}=3.6V$, $V_{OUT}=1.2V$, $I_{OUT}=1mA$)
MODE="L" \rightarrow MODE="H"



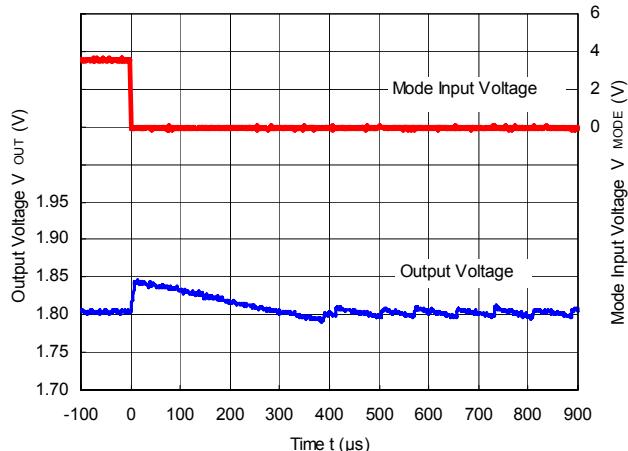
RP550K001A ($V_{IN}=3.6V$, $V_{OUT}=1.2V$, $I_{OUT}=1mA$)
MODE="H" \rightarrow MODE="L"



RP550K001A ($V_{IN}=3.6V$, $V_{OUT}=1.8V$, $I_{OUT}=1mA$)
MODE="L" \rightarrow MODE="H"



RP550K001A ($V_{IN}=3.6V$, $V_{OUT}=1.8V$, $I_{OUT}=1mA$)
MODE="H" \rightarrow MODE="L"





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Ricoh completed the organization of the Lead-free production for all of our products. After Apr. 1, 2006, we will ship out the lead free products only. Thus, all products that will be shipped from now on comply with RoHS Directive.